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Next Issue

Noteworthy improvements in practices and methods will be covered in our next issue, The Petroleum Engineer's fourth Annual Engineering Review Number to be published June 1.

Besides articles of a general review nature covering the industrial progress of every branch of the industry that will be written by our own men, we have obtained articles by prominent engineers, outlining progress and trends.

Articles by these outside authors will elaborate upon specific phases of the outstanding operating developments of the year. Production articles will include discussions on shallow producing methods as well as practices used in pumping the newer and deeper fields. In addition other articles of interest to production men will be those on such developments as bottom hole pressure, deep drilling, etc. Refinery articles will cover such subjects as cracking, manufacturing motor oils and progress in natural gasoline manufacturing. Pipe lines readers will be interested in an article on pipe line corrosion prevention investigations and practices and also in another article devoted to the application of electricity to pipe line pumping.

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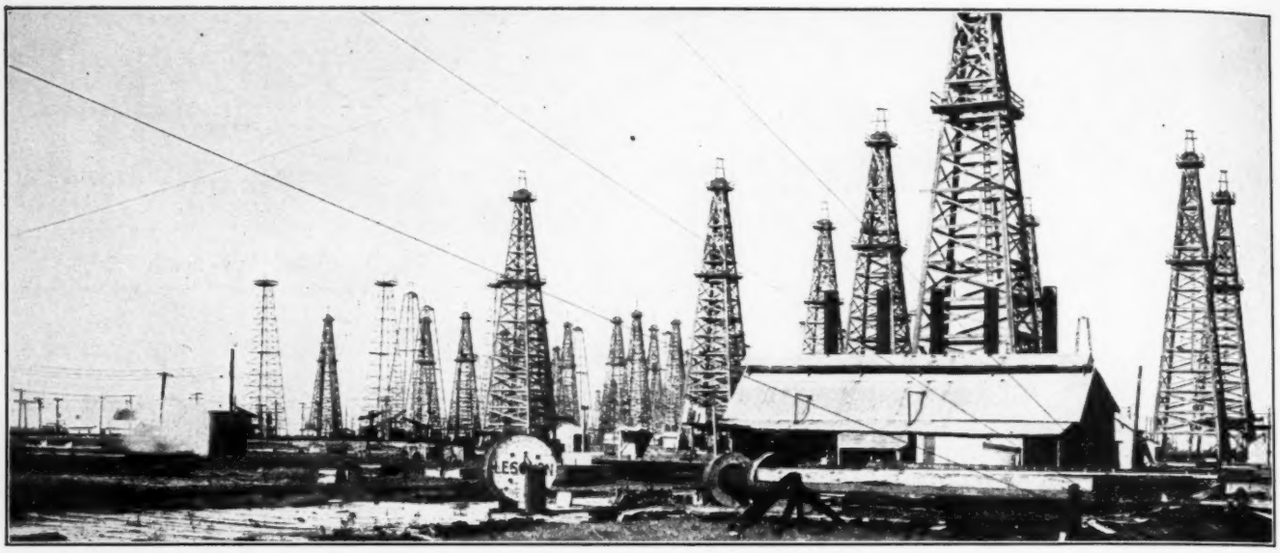

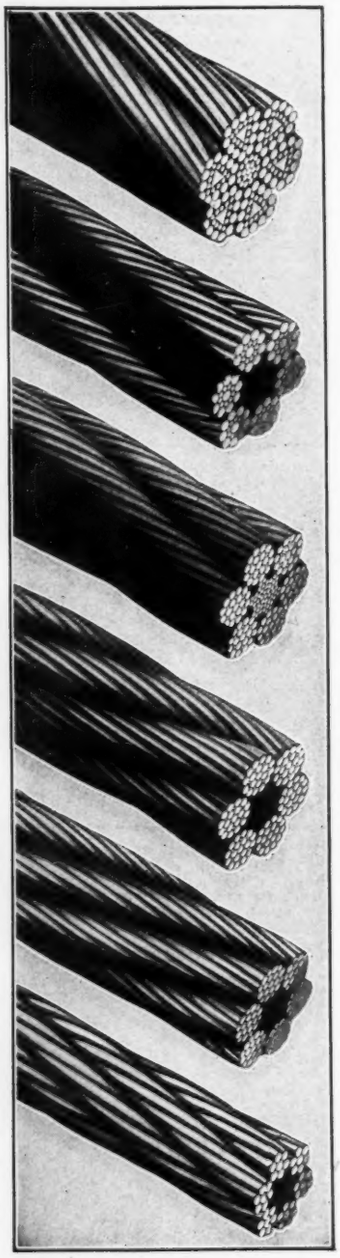

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The Course of Oil

By K. C. SCLATER

A Crisis Reached in East Texas

RAISING of the East Texas field allowable to 750,000 barrels a day, followed by the drastic drop in the price of crude to ten cents, precipitated a storm of bitter indignation and protest in oil circles. Many leaders in the industry were plainly dismayed at the turn events had taken . . . and well they might. It is inconceivable that this situation has been brought about by the fact that the petroleum industry, as great as it is, can only stand by, seemingly powerless to act, and look on at the spectacle of an unscrupulous few exploiting with impunity the East Texas field to their own ends by dealing in illicitly produced oil to such an extent as to place the entire petroleum industry on the verge of economic disaster. It is a classic example of how the unfair practices of a small minority in an industry can bring ruin to the great majority. No wonder those who have the future welfare of the industry at heart are left with a feeling of utter futility over the deplorable situations that can develop as a result of the vacillating policy that has been pursued in attempting to regulate production in the East Texas field.

A suit attacking the validity of the new order has been filed in federal court and is about due to come up for hearing as this is written. Meanwhile, a grave situation has developed over the exasperating turn events have taken the outcome of which at this time no one can predict. Until the validity or invalidity of the new order is established in court, and the subsequent course that the Railroad Commission will follow is learned, the full import of the commission's action in setting the high allowable can only be conjectured. Nor can much be inferred from a consideration of the circumstances surrounding the issuance of the order.

Conflicting requirements confronted the commission in writing a valid proration order for the East Texas field. First, it was necessary that it write a legal order or be cited for contempt of court; second, the daily per well allowable, according to an opinion rendered by the State Attorney General, could not be reduced below 40 barrels without violating the State marginal well law; third, the State conservation statutes requires that there be no physical or economic waste. Of these three requirements the first apparently gave the Railroad Commission the most concern in preparing the new order; the second requirement, the validity of which was a moot question, has now been removed with the enactment of the new marginal well law allowing wells in the East Texas field only 20 barrels daily; and the third requirement, which, although it contains the two factors of most vital concern to the oil industry, physical and economic waste, appears to have been ignored in writing the new order, this despite the fact that both these factors in the East Texas field have been the subject of many lengthy hearings before the commission at which it was clearly brought out that too high a rate of withdrawal from the field would result in both physical and economic waste. As viewed at the moment the order appears to repudiate all the dictates of good judgment and justice.

It looks now as if the intolerable conditions in the East Texas field will continue until May 15 at least, on which date the commission has called a hearing to determine the effect of the high allowable withdrawals on the reservoir pressure. Should the rate of pressure drop be great enough that in the opinion of the commission harm to the field will result, it is confidently hoped that the allowable for the field will be reduced to about 450,000 barrels. Such a course of action would have the approval of the entire industry.

If pending State legislation to enable rigid enforcement of proration is passed, and the present order for the East Texas field on the basis of 15 per cent of the hourly potential flow held valid by the courts, it is predicted that unfair practices in the East Texas field will eventually be stamped out. Regardless of the course adopted to regulate production in the field some inequities are bound to exist, but whether on the whole these are ever serious enough to justify adopting a course that results in endless wrangling in court, finally leading to a complete break-down of proration in the field such as just witnessed, is open to question. Only an empty victory is obtained if the result of such action has the effect of keeping the price of the oil below the cost of production.

Regardless of the ultimate course followed in producing the East Texas field, the fact cannot be escaped that if the field produces oil in excess of the amount the market can absorb, a decrease in price must eventually follow.

With these facts in mind it is difficult to understand why so much dissension is prevalent and so many factions exist in the industry, differing on obvious fundamentals. No doubt many operators in the field are being misinformed by reports deliberately designed to serve ulterior motives.

Effect on Refiners

Many small refineries and topping plants are springing up, directly as a result of overproduction. Legitimate operators of stripper wells in Kansas and Oklahoma have felt the pinch of competing with East Texas crude, and have been forced in the exigency to adopt the practice of topping the gasoline from their own crude and selling the product locally. These operators being in the center of large consuming markets are able to sell the residue from topping operations as fuel oil right on the lease, tank trucks taking delivery there. In this way they are able to realize more on their oil than the posted crude prices. What effect a large number of such plants will have ultimately on refining operations if present conditions continue may well be contemplated.

« Highlights in Oildom »

Excessive East Texas Allowable Brings Crude Price Cut

The East Texas crude oil price structure, which had remained steady at 50 cents per barrel for several months despite excessive production of oil, collapsed on the heads of operators there when the Railroad Commission announced an allowable production of 750,000 bbl. daily would be permitted the field.

This allowable almost doubles the former one of 400,000 bbl., and permits the pool to produce 37½ per cent of the United States' requirements and 23 per cent of the world's requirements. It also increased the production of the State of Texas to 64½ per cent of the United States' market requirements.

Led by The Texas Company, indignant crude purchasers immediately announced drastic cuts in scheduled rates, lowering East Texas crude oil prices to 10 cents per barrel. All major purchasers met the new price schedule, except the Magnolia Petroleum Company, which is paying 25 cents, the Gulf Company, which is quoting the "going price" (an average price based on the schedule of all purchasers), and the Sinclair Prairie Company and the Shell Corporation, which raised their price to 25 cents after paying 10 cents for a few days.

Not only did the major purchasers adopt lower prices but a few of them immediately inaugurated the policy of prorating takings from wells to less than the newly authorized allowable. In some cases this was physical necessity, since some pipe line facilities were not sufficient to handle the huge increase from all the wells to which they were connected. A number of East Texas producers have refused to produce oil and sell it at the present figure and have shut-in their wells.

Reduced quotations in other Texas areas soon followed, with postings of 20 cents for West Texas and Panhandle oil, 25 cents in North Central Texas and 30 cents in the Gulf Coast. A flat price of 25 cents a barrel was posted for North Louisiana, Arkansas, Kansas and Oklahoma.

Ferguson Signs Marginal Well Bill

The one bright outlook for the partial cure of the muddled conditions in East Texas was the signing of the marginal well bill by Governor Ferguson. The signing of this bill opens the way for a reduction of 200,000 bbl. daily in the production of the field, but as this is being written it has not been taken advantage of by the Railroad Commission.

California Reorganizes Curtailment Committee

In an effort to apply stringent curtailment to active producing fields of the state, California operators have reorganized the proration set-up. A new committee will represent California operators in an advisory capacity. This committee now has under consideration the problem of drawing up a new California proration plan and is also considering possible ways and means by which it may be successfully and fully applied.

Iowa Defeats Alcohol Blend Bill

Two bills that would set up state controlled alcohol distilleries and make mandatory the addition of 10 per cent alcohol in motor fuel sold within the state have been defeated in the Iowa state legislature. It now appears considerable difficulties still loom in the path of advocates of alcohol-gasoline blends.

Interest continues to run high in the proposal introduced before Congress that it enact a law requiring that all gasoline sold in the United States be blended with a 10 per cent volume of alcohol made from agricultural products. This represents the first attempt made in this country to compel motorists to use a certain fuel. It is being opposed by oil companies on the grounds that such a law would give the motorists an inferior fuel and that the prices would be higher.

Oklahoma City Shows Big Decline

The potential production of the Oklahoma City pool has declined 46 per cent, according to unauthenticated figures taken during the open-flow gauging period. It is interesting that many of those rating as big producers have showed tremendous increases in gas volume but huge losses in the volume of oil produced.

Increase Conroe Allowable

The Texas Railroad Commission's order, effective May 1, boosting the allowable production of the Conroe field from 35,000 bbl. daily to 60,000 bbl. gives each well located on a 20-acre unit an authorized recovery of 174 bbl. of oil per day. All wells were previously being permitted to produce 100 bbl. each per day.

New Oklahoma Proration Law Survives

The belief that the Oklahoma legislature may have succeeded in writing a legal crude oil proration law was strengthened when it survived the first court attack. The Oklahoma Supreme Court has denied the Champlin Refining Company a writ of prohibition against the taking of potentials in the Oklahoma City pool, as required by the new law. The new Oklahoma law is the most stringent one yet adopted by any state, providing heavy fines and imprisonment for violations.

Ban on Interstate Shipment of "Hot" Oil

A bill introduced into Congress would provide heavy penalties, including fine and imprisonment, for the shipment of crude oil produced in violation of any law of the state, territory or district where such oil was produced. The law also penalizes any one who receives or buys such oil.

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Latest Activities in the Oil Fields

PRODUCTION developments of the past month were featured by the definite proving of southern Polk County, Texas Gulf Coast, as an oil producing region. This sector has been one of the several closely watched areas considered as highly promising and the establishing of this belief will result, it is anticipated, in an immediate active drilling campaign. The wildcat play of the Texas Gulf Coast will also receive additional impetus as a result of this important strike.

Shell Petroleum Corporation opened the new pool, which is near the town of Livingston and will be known by that name, when the plugs were drilled in its No. 1 Davis test, which responded with an initial flow estimated at the rate of 3000 bbl. daily from a hole bottomed at 4334 feet.

The Conroe field, present center of activity on the Gulf Coast, was extended a mile westward by the completion of the Strake Petroleum Company's No. 1 Shaeffer for a flow of 100 bbl. per hour through ½-in. choke. The well adds approximately 2000 additional acres to the proven territory and is located in an area heretofore looked upon as condemned. This development will necessitate adjustment of previously made estimates on the size of Conroe.

Southwest Texas continues to be very active and to create additional interest because of several newly discovered productive pools and horizons. Jim Wells County sprang into the limelight when a new field was definitely opened by the Magnolia Petroleum Company with its No. 2 Seeligson that flowed five bbl. per hour on choke from sand at 3247-55 feet. This is the first production in this particular section of Southwest Texas, it being located 50 miles east of the Mirando pools and 25 miles west of the Kingsville field. It is thought that the new pool, referred to as Premont prospect, is situated on a dome-like structure, probably a deep seated salt dome.

The biggest oil producing well in the history of the Saxet field, Nueces County, has further strengthened the belief that the region will become a prolific producing area. The new completion made 50 bbl. per hour through a ¼-in. choke.

Possibilities for the development of a large Serpentine pool in the Hilbig area of Bastrop County seem to be waning as a result of three failures. The several producers in the field made high initial production, but the area apparently is quite limited in producing extent.

The East Texas field appears definitely to have passed the period of spectacular development. During the early part of the month completions averaged but four per day and during the last week an average of only three was maintained.

Two widely separated oil strikes in Michigan indicate the existence of a producing area seven miles long in Midland County. Pure Oil Company completed a well in Jasper township for 400 bbl. at 3440 feet. It is one mile southeast of three wells of the Pure Oil on the Yost lease, Greendale township, and about three miles south of the Chippewa-Greendale pool. The Pure's other well was a 5000-bbl. producer.

AVERAGE CRUDE OIL PRICES

California		Oklahoma	$ .44
Playa Del Rey	$ .69	Arkansas	.25
Coalinga	.49	Louisiana	
Long Beach	.75	North Louisiana	.25
Montana	.75	Gulf Coast	.30
Wyoming	.44	Illinois	.62
Colorado	.40	Kentucky	.57
New Mexico	.20	Indiana	.40
Texas		Ohio	
North Central	.25	Lima	.70
Panhandle	.20	Wooster	.70
West Texas	.20	Michigan	.85
Gulf Coast	.30	Pennsylvania	
Darst Creek	.23	Bradford	1.47
East Texas	.10	Corning	.70
Kansas	.44	West Virginia	1.12

Production and Refining Figures Furnished by the American Petroleum Institute

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks
Week Ending April 22, 1933

(Figures in Barrels of 42 Gallons Each)

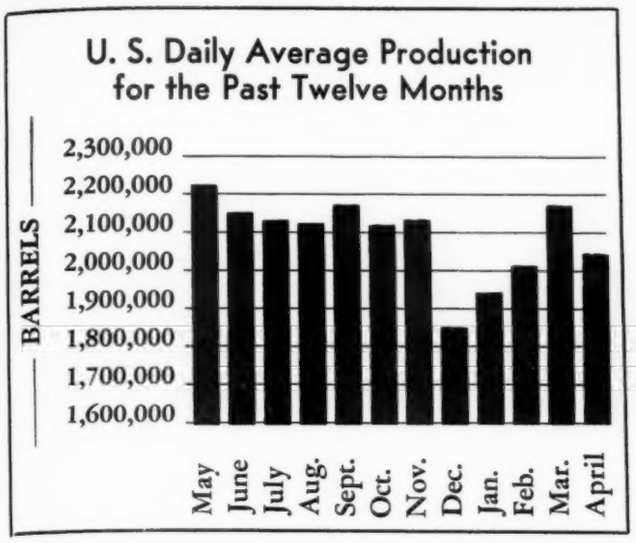
DISTRICT	Per Cent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Per Cent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbls.	Gas and Fuel Oil Stocks Thousands of Bbls.
East Coast	99.1	484,000	75.8	16,293	6,109
Appalachian	95.0	89,000	65.9	2,068	847
Ind., Ill., Ky.	97.5	295,000	69.6	8,623	3,550
Okla., Kans., Mo.	84.9	220,000	56.4	5,451	3,036
Inland Texas	56.4	81,000	45.6	1,763	2,117
Texas Gulf	97.7	448,000	82.7	5,504	5,896
Louisiana Gulf	97.3	100,000	70.4	1,527	2,034
No. Louisiana-Ark.	88.5	42,000	53.2	337	637
Rocky Mountain	90.8	34,000	24.6	1,458	645
California	94.6	414,000	47.8	14,327	97,783
Total April 22	91.6	2,207,000	62.5	57,351	122,654
Total April 15	91.6	2,201,000	62.3	57,916	122,372

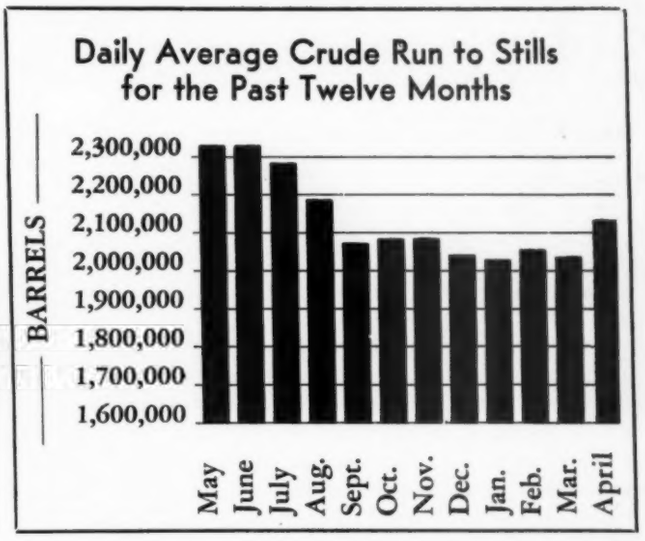
Daily Average Production
(Figures in Barrels)

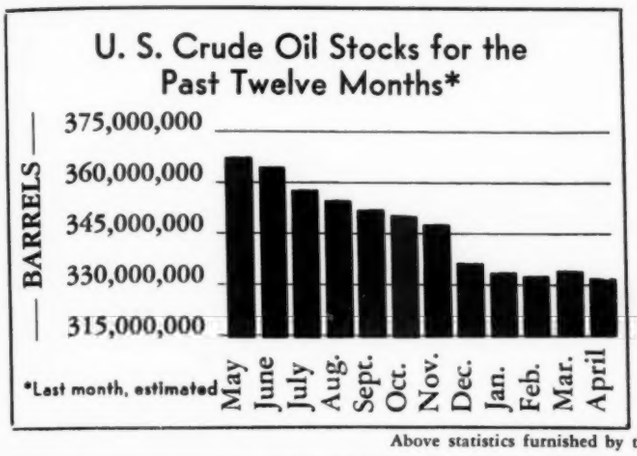
	Week Ended Apr. 22 1933	Week Ended Mar. 25 1933	Week Ended Apr. 23 1932
Oklahoma	377,450	563,800	468,950
Kansas	115,250	122,650	98,450
Panhandle Texas	43,800	55,150	52,550
North Texas	52,150	52,300	48,650
West Central Texas	23,300	22,800	24,850
West Texas	159,750	161,050	180,550
East Central Texas	58,250	58,600	56,550
East Texas	*	360,800	346,350
Conroe	41,150		
Southwest Texas	48,900	49,100	54,850
North Louisiana	29,900	31,200	29,450
Arkansas	30,200	30,850	34,900
Coastal Texas (Not including Conroe)	115,000	154,450	107,350
Coastal Louisiana	42,200	35,300	34,250
Eastern (Not including Mich)	87,600	87,200	104,350
Michigan	16,850	14,150	18,800
Wyoming	29,300	31,150	39,500
Montana	5,050	5,550	6,750
Colorado	2,350	2,500	3,400
New Mexico	36,250	37,350	37,100
California	480,800	373,700	520,300
TOTAL	*1,795,500	2,249,650	2,267,900
Texas	542,300	914,250	871,700

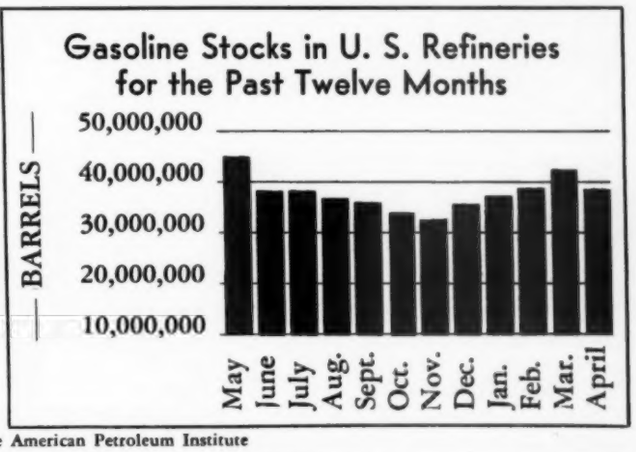
* East Texas figures represent the week ended 7 a. m., Tuesday morning, April 18, and reflect the complete shut down during that week.

NOTE: Stocks at refineries, except in California district, which includes stocks on finished gasoline and engine distillate at refineries, water terminals and sales distributing stations and amounts in transit thereto.









Above statistics furnished by the American Petroleum Institute

Summarized Operations in Active Fields for March, 1933

Fields	Completions	Producers	Locations	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas									
East Texas	138	134	114	49	49	3600	2	40	Rotary
Duval County	19	15	8	7	40	2300	2	22	Rotary
Conroe	84	82	79	15	53	5200	2	38	Rotary
Oklahoma									
Oklahoma City	9	9	4	3	7	6500	3	39	Rotary
Kansas									
McPherson	12	10	13	7	31	2900-3400	2	38	Rot.-Cab.
Ellsworth Arch	12	6	17	9	28	3300	4	37	Cable
California									
Kettleman Hills	0	0	1	2	14	8300	3 or 4	40	Rotary
Long Beach	10	10	1	1	11	7000	3	26	Rotary

Field Activities by States for March, 1933

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1932 (In Barrels)
	April	March	April	March	April	March	April	March	April	March	
Arkansas	3	1	1	0	3	1	16	19	26	25	11,907,000
California	22	24	20	23	29	27	16	15	120	92	178,128,000
Colorado	8	4	1	1	....	1	8	5	56	59	1,177,000
Illinois	1	3	0	1	....	....	1	2	10	10	4,661,000
Indiana	16	13	12	8	....	....	2	2	53	59	804,000
Kansas	55	28	37	21	69	41	29	35	89	91	34,300,000
Kentucky	9	3	5	2	....	....	3	2	41	45	6,264,000
Louisiana	41	38	25	14	48	33	39	31	124	116	21,478,000
Michigan	14	12	9	9	29	30	50	51	75	71	6,729,000
Mississippi	3	2	0	0	....	....	3	4	15	12	Gas. Prod.
Montana	2	6	2	4	....	....	4	5	30	36	2,449,000
New Mexico	4	4	3	4	....	....	6	9	59	59	12,511,000
New York	4	9	3	9	....	....	2	1	9	6	3,501,000
Ohio	46	39	34	35	93	....	31	33	109	106	4,597,000
Oklahoma	89	91	61	62	....	74	87	120	286	301	152,621,000
Pennsylvania	35	28	25	25	470	....	30	7	93	85	12,403,000
Texas	466	408	332	283	....	383	195	234	694	689	311,069,000
West Virginia	23	21	19	21	....	....	14	7	34	37	4,472,000
Wyoming	1	2	0	1	....	....	8	9	58	63	13,359,000
Total	842	736	589	523	741	590	544	591	1981	1962	781,845,000

Progress of Major Pipe Line Work

By WARREN L. BAKER

THE starting of several important pipe line construction projects during the past month has increased the amount of transmission system activity to its highest peak in six months or more.

Oil Lines

Sinclair Prairie Pipe Line Company has awarded contracts for removal of 140 miles of 12-in. pipe between McCloud, Oklahoma, and Coffeyville, Kansas, and for re-laying it between Teague, Texas, and Huffman station, 26 miles north of Houston. The work will be done by two contracting companies, Truman Smith Construction Company, which will take up and re-lay 73 miles of the southern portion of the line, and Meador & Whittaker, who will have charge of both operations on the 67 miles comprising the northern section. H. C. Price, Inc., will do 50 per cent of the welding and cutting work with the Lincoln Electric "Fleetweld" process; the remainder will be done by the Linde Air Products Company. The new 12-in. line will call for additional pump stations and the installation of more pumping units at existing stations, but plans for these have not been announced.

The Sinclair job will create the largest labor demand during the summer months of any single oil industry project in the southwest. The line will be stripped of its soil coverings and cut in 40-ft. lengths, original joint welds eliminated, then shipped by rail to Texas.

The capacity of Atlantic Pipe Line Company's 10-in. trunk line running from the East Texas field to Atreco, Texas, tank terminals on the Gulf of Mexico, will be increased from 30,000 to 40,000 bbl. daily capacity through the erection of two additional stations. These will be identical with the station at Zavalla, Texas, which has attracted extraordinary attention because in it was introduced the first application of Diesel engines direct connected to electric generators for generating power to drive pumps. One station will be erected below Mount Enterprise, Rusk County, and the other near Silsbee, Hardin County.

Kelly-Dempsey Company has completed construction work on the Phillips Petroleum Company's 210-mile 8-in. line from Oklahoma City to Thrall Station, near Eureka, Kan., and also the building of two loops on the Phillips main line from Eureka to Kansas City, Kan. Pump stations are now being erected at Oklahoma City, Yale and Burbank, Okla., and Howard, Kansas.

Construction work on the Channel Transport and Marketing Company's 8-in. oil line, extending from the Conroe field to tank farm and tanker terminal facilities at Norsworthy on the Houston ship channel has been completed by the contractors, Apex Construction Company. This line, the fourth tank outlet for the Conroe pool, has a rated capacity of 24,000 bbl. per day, which can be increased to 36,000 bbl. daily by the erection of an intermediate station, when desired, on the 34-mile stretch.

Two new pipe lines will be built to serve the growing production of the Ellsworth-Barton Arch area of Western Kansas. Upon completion of the work pools in this region will have their first pipe line outlets, lack of which has been a major factor in holding back development. Stanolind Pipe Line Company has commenced preliminary work on a 6-in. welded oil line that will extend from the Raymond pool in Rice County through the Orth pool to the Holyrod area of Ellsworth County. Laterals to be built from this main line will serve the Chase Townsite, Strattman and Stoltenberg pools. The second project of this region is the Sunflower Refining Company's 6-in. line from the town of Lyons in central Rice County to the Orth pool, a distance of 14 miles. From the Orth pool a 4-in. gathering line will connect the Heiken and Breford pools, while another 4-in. lateral will run southwest to Chase Townsite. At Lyons the new 6-in. will tie in with an existing 8-in. line running to the company's refinery at Hutchinson, where 2000 bbl. daily is going to stills. As soon as the line is finished runs will be increased to 3000 bbl. Joseph Construction Company of Wichita is the contractor on the Sunflower line.

Humble Oil & Refining Company is constructing a 6-in. pipe line from its wells near Red Rock, Bastrop County, Tex., to its Luling pump station, a distance of about 30 miles. Some 200 men are employed, with headquarters at Lockhart.

Gasoline Lines

Work has started on the jointly owned 80-mile 6-in. gasoline carrier between Toledo, Ohio, and Detroit, Mich., belonging to the Pure Oil Company and the Sun Oil Company. Ford, Bacon & Davis, Inc., has been awarded the contract and has established an office at Monroe, Mich. It is estimated the work will require two months and about 500 workmen will be employed. Pipe for this project, totaling 4500 tons, has been ordered from the Youngstown Sheet & Tube Company and the National Tube Company. The line will be operated under the name of the Detroit Southern Pipe Line Company.

Derby Oil Company of Wichita, Kan., will be the first Kansas oil concern to move motor fuel by pipe line. Construction is well along on the company's 4-in. 58-mile line from its refinery at Wichita to a terminal being built south of McPherson, Kan. Pritchard Construction Company, Kansas City, Mo., contractors, have strung all of the pipe and welding is now in progress. From the McPherson terminal, Derby products will be distributed to near-by towns in tank trucks and also shipped to Nebraska and Colorado territory by tank cars.

Natural Gas Lines

Canadian Western Natural Gas, Light, Heat and Power Company of Calgary, Canada, is planning to spend $90,000 on replacements and improvements to its transmission system in southern Alberta during the summer months.

The El Paso Natural Gas Company proposes the building of a 200-mile gas line to supply the cities of Tucson and Phoenix, Ariz., with natural gas. The line would run from El Paso, Tex., to the above cities. The company has made application to secure a loan of $2,100,000 for financing the construction from the Reconstruction Finance Corporation, and, if the loan is approved, the line is certain to be constructed.

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The Month's Activities in Refining

By F. R. STALEY

Per cent refining capacity operated

Eastern Division 69.0% Central Division 63.7% Western Division 46.3%

IT is reported that the Pan-American Petroleum and Transport Company, a subsidiary of the Standard Oil Company of Indiana, will soon start construction work on a new refinery on the Houston Ship Channel in Texas. The plant, it is expected, will be of 50,000-bbl. capacity, cracking type. This company has owned a site on the channel for some time but has delayed the erection of a refining plant.

Southwestern Engineering Corporation, Los Angeles, has been awarded a contract for the installation of a large fractionating column for the Caminol Oil Company. The new tower, which will enable the company to make high-grade specification gas oil and kerosene, is to be located at Caminol's Hanford, Calif., plant.

A unique situation has arisen in many producing states where numerous very small refineries are being constructed, some of which operate solely for private consumption. Construction of two small refineries is under way at Conroe, Tex., both on the southern edge of the field along the I. & G. N. railway right-of-way. These are being built by the Rainbow Oil and Refining Company and Munhall Refining Company. Each company proposes a 300-bbl. plant. The Falcon Refining Company is building a skimming plant of 250-bbl. capacity at Great Bend, Kan. This refinery will operate on crude oil produced in the Ellsworth Arch area of western Kansas.

George Sonricker of Breckenridge, Tex., and Arthur Tucker of Graham, Tex., are constructing a 400-bbl. refinery in the McMillan pool. A five-year contract has been signed with the Golden Petroleum Company by which the latter is to supply a minimum of 25 bbl. daily to the plant.

Among the states afflicted by the building of these small refining plants, Wyoming is probably the "hot-bed." Some time ago county agricultural agents of Wyoming distributed circulars telling how individual farmers could distill their own gasoline from crude oil with a barrel and a set of coils. In the Cut Bank and Kevin-Sunburst fields more than 200 bbl. a day are being sold in barrel lots as a result. The fad has spread so rapidly that it has become necessary for oil operators to organize for the purpose of discouraging small-lot sales. Reports state that there are 22 of these plants in the Osage district of Wyoming alone. The same situation applies to the settled production area of Kansas, although in this region it has not yet become acute. Steps are being taken by oil operators in other states to stop the sale of crude to these small plants.

The Chicago Bridge and Iron Works will erect for the Sinclair Refining Company at Houston, Tex., four 80,000-bbl. welded storage tanks equipped with Wiggins pontoon floating roofs.

Many states are taking drastic steps to check tax evasion on gasoline, this having become a serious menace to the refining industry. The Ohio tax commission has recently put under its control 76 small plants and distillation units. The plant operators are granted licenses and made responsible for the distilling operators. For the purpose of checking gasoline tax collections, Kansas and Colorado have recently passed regulations affecting transportation of gasoline in motor trucks.

In order to prevent substitution many refiners are now placing their motor oils on the market in small sealed cans that must be destroyed in the opening. As a result of this method some companies are reporting an increased sales volume.

The Ethyl Gasoline Corporation is offering refiners and marketers holding Ethyl contracts its "Q" brand of lead anti-knock compound. This brand is to be used in gasoline rating next to regular Ethyl in price, not to exceed 70 octane. The fluid may be colored any desired shade except red. This type of gasoline can be sold starting June 1.

Another experiment with alcohol-gasoline motor fuel for commercial use has been started in north central Illinois by the Illinois Farm Supply Company. This test will be made with a blend containing five per cent anhydrous alcohol. The five per cent blend will be distributed from bulk plants at Plainfield and DeKalb of the farm bureau companies. Tests of the 10 per cent blend, started March 11, will be continued by the farm bureau oil companies for the remainder of the 90-day test period and the results will be compared with the results of the five per cent blend test.

Natural Gasoline

The $250,000 gasoline absorption plant of the Royalite Oil Company in the Turner Valley field of Canada is now about 75 per cent completed. The plant should have been finished by this time except for bad weather conditions. Gasoline will be extracted from the residual wet gas of the Royalite and other wells after the first naphtha recovery has been made by means of separators.

The Texas house of representatives has passed a bill that will permit gas operators in the Texas Panhandle field to process gas for the recovery of casinghead gasoline and to burn the residue gas to make carbon black until such time as gas pipe line companies buy the gas for fuel purposes. Lack of sufficient gas markets for production in the field had previously resulted in many companies having to shut in their wells while offset acreage was being produced. As a result of this new order, which becomes effective if signed by the Governor 90 days after recess of the legislature, gasoline manufacturers are expected to become quite active in this territory.

The Arkansas-Louisiana Pipe Line Company will build an 8000-gallon capacity absorption plant in the Rodessa field, Caddo Paris, La. The equipment includes a Southwestern distillation unit and six 24-in. absorbers.

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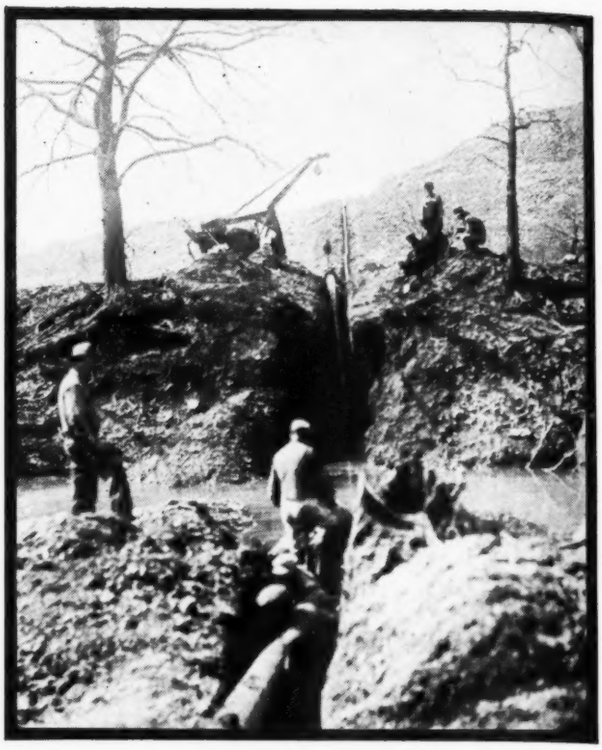


Many bends were required in the Flint Hill region of Southern Kansas

Laying of P

By H. B. CROWELL
President, Kelly-Dempsey Company

THE longest pipe line construction project yet announced for 1933 has been completed and the Independent Pipe Line Company, crude oil transportation subsidiary of the Phillips Petroleum Company, has thereby expanded its main line transmission system south from Eureka, Kan., to Oklahoma City, Okla. This new line is an important link in the Phillips system, as it assures the company's recently enlarged Kansas City, Kan., refinery of an abundant crude supply. The routing of the line is such that it provides available outlet facilities for important Phillips producing properties at Burbank, Cushing and Oklahoma City, Okla. In the latter field especially does the company have a huge actual and potential production.

So little expansion construction work of major importance has been done on pipe line transportation systems in recent months that this line created extraordinarily great interest.

Rapid progress was made by the contractors in the construction of the Phillips line, an 8-in. high-pressure crude oil carrier that extends from the Independent Pipe Line Company's new pump station on the north edge of the Oklahoma City oil pool to Thrall station, near Eureka, where it ties into a previously existing 6-in. line running 110 miles northeast to Kansas City. The total time required for the completion of the 210-mile project was approximately 75 days, or an average of almost three miles a day. The daily progress report shows that up to more than 18,000 ft. (roughly 3½ miles) of construction was completed by one crew in a nine-hour working period. While such records are possible only with favorable weather conditions, it nevertheless represents remarkably fast time and has attracted considerable attention. Although few unusual construction problems arose, much of the territory traversed, notably in the Flint Hill region of Kansas, could not be termed ideal pipe line terrain as numerous pipe bends were necessary. Several major rivers were crossed; these and the rocky area of Kansas demanded ingenuity. One factor faced in the laying of this line that renders the speed record more impressive was the use of comparatively inexperienced labor.

A contract for the laying of this line was awarded the Kelly-Dempsey Company, Tulsa, Okla., and the terms included also construction of the two 8-in. loops (entailing nearly 50 miles of additional work) on the company's main line from Thrall station to its Kansas City refining plant. One loop, approximately 33 miles in length, was made near Burlington, Kan., and the other, 16 miles in length, near the town of Olathe, Kansas.

The Oklahoma City to Thrall section is now entirely completed, while the 16-mile loop at Edgerton station, near Olathe, was recently finished and is now in service. Satisfactory progress is being made on the remaining loop near Burlington.

Three construction crews were employed on the project. These were worked from three different sites northeastward throughout the duration of the job, except in southern Kansas, where the character of the surface formations required more than the usual amount of man power. Due to the present unemployment situation, the contractors hired laborers from the immediate vicinity traversed by the route of the line. Although this program brought about a too rapid turnover in labor, highly satisfactory results were obtained and temporary unemployment relief accrued to the various communities. Many congratulatory letters expressing appreciation for the co-operation thus extended have been received by the contractors from civic organizations along the line. Between 500 and 600 laborers were employed throughout the construction period.

Work was started early in February at the southern terminus, Oklahoma City. Favorable weather enabled the contractors to complete ready for service the section between Oklahoma City and the Phillips Petroleum Company's tank farm near Yale, Okla. (a distance of 64 miles) by March 1st, or in less than three weeks time, despite the fact that the north branch of the Canadian river and the Cimarron river had to be crossed. Upon completion of this portion of the project, the Independent Pipe Line Company was afforded an opportunity, by installing a temporary pumping station, to commence shipments of crude from the Oklahoma City field north to the Yale tank farm, where tankage facilities were sufficient to accommodate additional storage.

The construction crews were then concentrated on the portion of the line running from Yale to the Phillips tank farm located in the Burbank field at Shidler, Okla., a distance of approximately 50 miles north of Yale. This section was completed by April 1st, although on it the crossing of the Arkansas river and the rough Osage mountain territory was necessary.

Construction was then continued northward to Thrall station, and it was in this section that the more serious problems were encountered. These problems, in the main, were oc-

Gang making a bend to conform to a steep drop near Cedarvale, Kansas

f Phillips Pipe Line Is Completed

Four river crossings and blasting ditch through Flint Hill region of Kansas were major difficulties

casioned by the flint ridge region of southern Kansas, where it was necessary that the trench be made through solid rock and where deep canyons and bluffs without number had to be traversed. Much of this work could be done only by man power and by blasting. Sixteen portable air compressors and jackhammers were maintained in service 24 hours a day to drill sufficient ditch to meet the requirements of the pipe-laying gangs. More than 40 tons of dynamite were also consumed in blasting away rocks for the trench alone. Such rough and rocky terrain also required the making of many sag and side bends. These were made in the field in the customary manner with tractors and booms.

In crossing several of the extremely deep canyons through this flint ridge district near Cedarvale, Kan., it was impossible to operate machinery at the site to bend the pipe. In these cases several sections were welded together, sections some times as long as 600 to 800 feet. This operation was performed on the top of the bluffs, as was that of bending the pipe to the desired angle. This work completed, the sections of pipe were placed in the trench by lowering them over the sides of the bluffs with winch lines. This procedure required careful and skillful handling in aligning the pipe with that already in the ditch, while at the same time making the pipe fit the sharp changes in elevation.

The pipe used in constructing the Phillips line was manufactured by Republic Steel Corporation, being their electric resistance weld pipe of 8 5/8-in. O.D., weighing 24.69 lb. per ft., and having a wall thickness of 0.227 inch. The pipe was of double length, averaging close to 45 ft. per joint. The field welding was done entirely by H. C. Price, Inc., of Bartlesville, Okla., and the electric shielded arc process was used throughout. The welding machines and "Fleetweld" electrodes were manufactured by the Lincoln Electric Company of Cleveland, Ohio. An average of 30 welders were employed.

Immediately upon completion of each section of the line it was carefully and thoroughly tested. The procedure was to install a recording pressure gauge and to build up a liquid pressure of 1200 lb., after which the gate valves were closed for 24 hours for inspection before being passed as satisfactory.

Although four major rivers were crossed by the line no serious difficulties were encountered, due largely to the extremely low water level prevailing in each. These rivers were the North Canadian at Oklahoma City, the Cimarron, near Cushing, Okla., the Arkansas in the vicinity of Ralston (north of Pawnee, Okla), and the Neosho on the loop near Burlington, Kan. In the first three mentioned rivers, the banks and beds were very sandy and the principal problem was to keep the ditch clean until the pipe could be placed in the trench.

The daily rated capacity of the Independent pipe line is 20,000 bbl. with booster stations, which are now being constructed, at Oklahoma City, Yale and Burbank, Okla., and Howard, Kansas.

Adaptation of the Fractionating Still to Absorption Plant Stabilization » »

By T. B. LEECH
Refinery Construction Engineer

LARGELY as a result of the advent and construction of cracking processes of various types with their attendant creation of gas, refiners several years ago turned their attention to the extraction of the gasoline fractions contained therein. Purely from a practical standpoint, without great concern for any theory involved, there were originally largely only two methods considered for asorbing the valuable hydrocarbons from the gases.

In the first of these methods refinery naphtha was circulated through either a baffle-type or bubble-type absorber counter-current to the plant gases evolved from the various processes. Whatever extraction took place was accepted, as it apparently substantially increased plant yields. Gas after leaving the absorbers went to the burner lines. Enriched naphtha either before or after treatment was blended with the refinery gasoline. In the second method absorption was conducted as in the first, but gas oil was used as the absorbing medium. This gas oil was either cold cycle stock or fresh feed to the cracking unit. After leaving the absorber the enriched gas oil was either ultimately fed into the cracking still fractionating tower or became part of the feed to the cracking coil.

Further study and continued demands for greater efficiency demonstrated that in the great majority of cases neither of these methods was sufficiently effective to retain its place in a modern refinery.

The naphtha method was objectionable in various plants on one or more of the following counts:

1. The naphtha itself frequently had too high a vapor pressure to be an effective absorbing agent.
2. There was seldom enough naphtha, without expensive provisions to produce it, to remove effectively the most desirable (butane and heavier) constituents of the gas.
3. Due to the absorption of undesirable constituents (iso-butane and lighter) the naphtha, when mixed with the gasoline for ultimate sale, tended to increase the vapor pressure of gasoline and so slightly increase the loss of that valuable product, thus partially nullifying the benefits of the naphtha absorption.
4. In the extreme cases the naphtha-to-gas ratio was so low that naphtha was actually decreased in quantity though raised tremendously in gravity.
5. As end points of gasoline were progressively decreased from year to year and vapor pressure limits were decreased on finished gasoline, the naphtha absorption system became less effective due to accentuation of the above mentioned objections to it.

The gas oil method of absorption was objectionable on one or more of the following counts:

1. The high molecular weight of the gas oil indicated that it was not a most desirable absorbent as a greater quantity of it had to be circulated than would have been necessary with a lower molecular weight oil to obtain the same degree of gas stripping.
2. Without upsetting the cracking plant cycle there was frequently not enough gas oil effectively to strip the gas of its major butane and heavier content.
3. As the enriched gas oil returned to the cracking still fractionator either before or after passing through the cracking coils, it carried with it all the iso-butane and lighter constituents it had absorbed. These hydrocarbons came overhead with the cracked gasoline and thus actually increased the undesirable light constituents in the gasoline. This reacted in two ways:

(a) Presence of the added gases decreased the condensation of desirable gasolines and increased the load to the absorber.

(b) The continuous recycling of the light hydrocarbons decreased the amount of butanes and heavier absorbed, until ultimately a condition of equilibrium was achieved with a much lower absorption factor, and less gasoline production, than if the absorption oil had been distilled in a separate column.

4. If the rich absorption oil was circulated through the cracking coils presence of the light gasoline somewhat upset and retarded the cracking operation and in certain cases portions of the absorbed gasoline were undoubtedly cracked into uncondensable gases. These objections were studied in the light of theory developed by technical men. It was, in general, found that pentanes and heavier, good salable motor fuels, were escaping in the supposedly stripped gas while often lighter constitutents to a harmful degree were retained and finally passed on into motor fuel. As a result of these studies new refineries being built were equipped with complete conventional absorption plants to process the gas. This equipment was also added to many old plants.

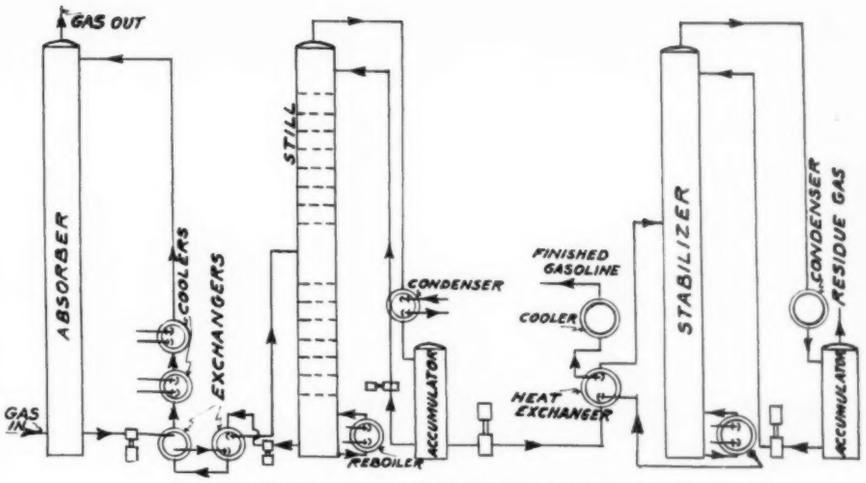
Most of these absorption plants were built on the correct theoretical formula that it is necessary to take not more than two closely fractionated streams from any given fractionating tower. As a result the enriched absorption oil from a bubble type absorber was usually stripped in a combined still and fractionating column, the lean absorption oil returning to the absorber through necessary exchangers and coolers and the overhead condensed gasoline was sent to a stabilizer. The stabilizers were commonly designed for equilibrium conditions of temperature and pressure so that propane and lighter would be taken overhead, ultimately going to gas lines, and so that the absorbed butanes would be left as a bottom product.

In general, refineries found that if all available pentanes and heavier were retained that only part of the butane could be put into the motor fuel. They found that they either could not use all their absorption-stabilized gasoline because it had such a high vapor pressure that all of it could not be blended with straight run or cracked motor fuel, or they found that after having installed high-pressure stabilizers that they had to run them at lower pressures in order to eliminate butanes and produce a satisfactory low vapor pressure gasoline for blending purposes. It thus appears that where the first two methods of absorption discussed were inefficient in that all the desirable heavy constituents contained in the gas were not extracted, ultimately to become a part of motor fuel, and that extremely light hydrocarbons were frequently retained to a harmful degree, that the newer processes, theoretically correct in the absorption phase design, are uneconomical in many plants.

As a result of these facts an inexpensive and low-cost-operation process was sought that would effectively absorb all the pentanes, together with an effective quantity of the butane

from the gas, and produce the maximum quantity of relatively low vapor pressure gasoline suitable, except for treating, for blending into motor fuel.

A discussion of design that meets these requirements follows. This design is particularly applicable to absorption plants operating in conjunction with cracking units or where a direct-fired pipestill can be used to supply heat to the absorption plant. Referring to the sketch, "Absorption Plant With Fractionating Still," it will be noted that all plant gas goes through the bubble-type absorber, where it can be stripped of all available pentanes and heavier, together with a large percentage of butane; the exact extraction of butanes depending on the economics of the particular refinery in which the plant is to be installed.

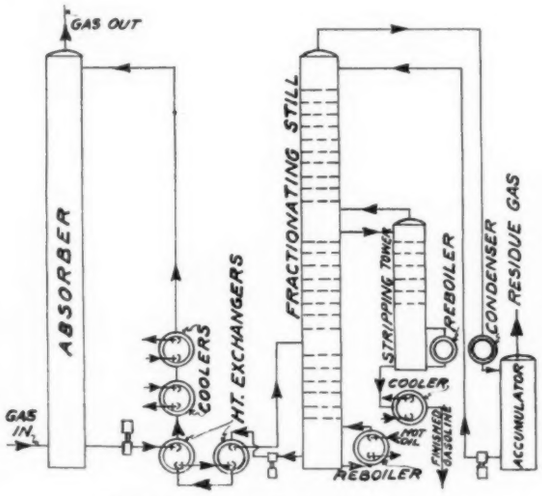


Conventional absorption plant and stabilizer

The enriched absorption oil leaving the absorber is pumped through exchangers and into the fractionating still. It will be noted that this still, with its side stripper, differs radically from the conventional absorption plant stripping still. Its operation is also unusual. Stripped absorption oil is taken from the bottom reboiler, gasoline of a specified vapor pressure from the side stripper, and the residue gas that commonly comes from stabilizer accumulators is taken from the still accumulator.

Oil enters the still at a temperature of approximately 450 deg. fahr., depending upon heat exchange, temperature of lean oil at still outlet, heating medium and still operating pressure. This latter is wholly dependent upon the overhead constituents and water temperature.

In general, so much of the iso- and norma-butane can and will be absorbed that between 40 and 50 per cent of the butanes must be eliminated from the gasoline in order to produce a satisfactory blending product. In this case the still pressure will vary from 90 lb. to 100 lb. absolute with a temperature of 80 deg. fahr. at the top. This assumes an oil of 165 molecular weight and a temperature of 550 deg. fahr. at the bottom. Hot cycle gas oil from the cracking plant at a temperature of 560 deg. fahr. is anticipated as the heat medium through the reboiler. In case water conditions preclude obtaining a temperature of 80 deg. fahr. at the top of the column, the pressure can be raised and an absorbent of lower molecular weight used, maintaining the same bottom temperature, or the pressure can be raised, the same oil used and a slightly higher bottom temperature be maintained. Proper relation of these conditions assure lean oil being completely stripped of gasoline content and that the column will produce the required product with a minimum loss.



Absorption plant with fractionating still

Lean oil passes from the still to the heat exchangers, coolers and back to the absorber. Pumping may or may not be required, depending upon the relative pressure of the fractionating still and the absorber. Gasoline is drawn from the side of the main fractionating column into a side stripper with a small stripping reboiler on the bottom. This reboiler needs to raise the temperature of the side drawn material only a small amount to insure the specified product. As the temperature of this reboiler is always well below the main reboiler temperature the same heat medium can be used in series through both items of equipment. Gasoline from the side stripper needs only to be cooled and sent to storage. Residue gas from the accumulator can go to the fuel lines. This entire process has definite limitations:

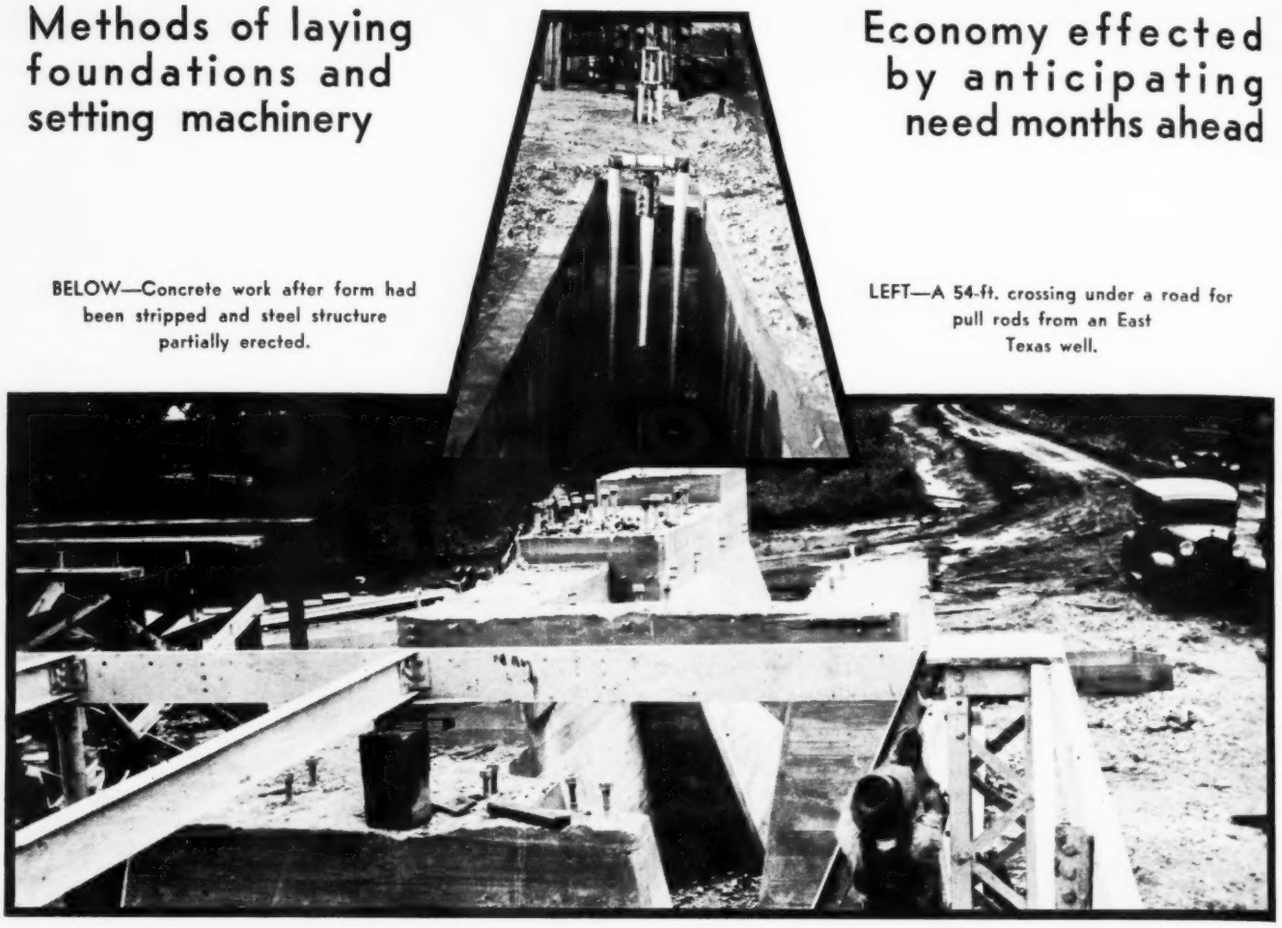
1. It can only be applied in refineries that wish to absorb and retain all the pentane and heavier, but that cannot use all the available butane. To attempt to raise the fractionating still pressure to a point where all absorbed butane would be recovered would make it almost impossible to strip absorption oil with any available heat medium.
2. Water temperature for this particular type of plant should be somewhat lower than for the average gasoline plant in order that fractionation may be effective and without the necessity of raising the still pressure unduly.
3. Oil of lower molecular weight than is generally required should be used.
4. The use of recycle stock as a heat medium prevents the cycle stock from returning to cracking coils as hot as it might otherwise. In only a few types of cracking processes is this important. In these the temperature must be raised by heat exchange or the heat input to the absorption cycle must be replaced in the cracking still furnace.

On the other hand, there are several distinct advantages to this type of installation:

1. It decreases total water consumption figured against complete absorption and stabilization plants.
2. Any well-built refinery can make its own low molecular weight absorption oil as required. If the oil becomes contaminated it can be thrown back into the crude cycle and replaced with fresh oil.
3. It eliminates any unnecessary cycling of gas through any other portion of the refinery proper, or through the absorber, or a re-absorber.

Methods of laying foundations and setting machinery

Economy effected by anticipating need months ahead



BELOW—Concrete work after form had been stripped and steel structure partially erected.

LEFT—A 54-ft. crossing under a road for pull rods from an East Texas well.

Installation of Pumping Equipment in East Texas Field

By DEWEY T. ROSS
Consulting Engineer and Contractor

NEXT in importance to the selection of the pumping equipment for a well is its proper installation. This is particularly true in the East Texas field where climatic conditions are such that if low installation costs are to be obtained the time or season of the year must be taken into account, for heavy rains can add greatly to the cost of installation whereas if the weather is fine, construction work can be expedited and installation costs held to the minimum. Many areas within the East Texas field are low lying and have the very poorest of soil conditions for the laying of concrete foundations, hence, the installation of concrete foundations requires more than ordinary attention if the job is to be permanent and satisfactory. Aside from the fact that a good concrete foundation will in the end pay for itself through maintaining the surface equipment in proper alignment, there is the added advantage that the absence of interruptions in pumping operations will reduce lifting costs and increase the total revenue from oil. Surface equipment improperly installed will subsequently give trouble; misalignment usually results, thereby causing excessive wear and tear and power losses so that to keep the well operating efficiently becomes a continual source of worry to those in charge of lease operations.

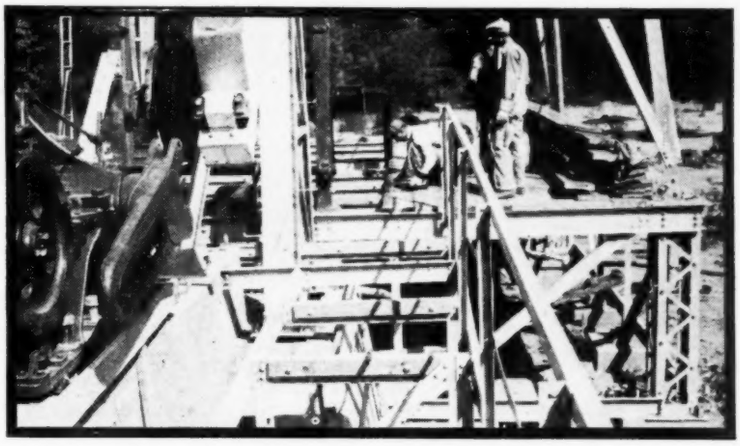
Too little attention has been paid in the past to the matter of economy in installing surface equipment for pumping wells. The better operators are gradually discarding haphazard methods of installing surface pumping equipment. Concrete foundations are laid and all surface machinery set according to up-to-date engineering practice and with due regard to the local soil conditions, topography and climate.

Conditions in the East Texas field for the installation of surface equipment for pumping wells vary widely. For example, on almost all locations along the river bottom it is necessary to make foundations that present a large bearing surface and to carry them to a very shallow depth only, because the top soil is firmer than that immediately underlying it. At most of the locations on high ground, however, it is necessary to remove the top soil and to seek a firmer soil beneath. Then again the matter of water level has to be considered. Heavy seasonal rainfall in this region causes flooding and a rise in water level of several feet in parts that are generally dry the better part of the year.

To date many interesting installations of well pumping equipment have been made in the East Texas field. At one location (see illustration), which is of especial interest, the

concrete forms are approximately 11 ft. in height at the highest point. This location is in the bed of Flag Lake, which normally has only a few feet of water but in flood periods may have a rise of as much as 10 ft. of water. It was necessary to reinforce and brace the forms very rigidly before the concrete was poured. Two of these high substructures have been installed. On the first location the form was made sectional so that it could be taken apart easily and used on the second location. On the second of these two high concrete structures the lake had been partially drained before the concrete foundations were laid. Approximately 110 cu. yards of concrete was used and more than 100 cu. yards of it was poured in one day, thus forming a one-piece concrete block. About five carloads of sand and gravel and almost 500 sacks of cement were required on this job. All the forms and anchor bolts were set with the aid of a level. A steel substructure was erected on the corner piers and formed a base for the derrick. The derrick floor level was placed about one foot above the top of the concrete cellar.

Laying an East Texas rig floor after steel work is completed and machinery is in place



Steel substructure erected on corner concrete piers also serves as the base for derrick

In placing the machinery on the concrete the heavy pieces were raised with a winch truck by means of a line thrown over the top of the derrick. In this operation considerable precaution was necessary to make the bridle and slings secure, as the weight of one of the heaviest parts was more than four tons. A snub line was used to maneuver the unit into position before lowering it onto its foundation. As an example of the effect of weather conditions on the speed at which construction work of this nature can be carried out, 28 wells of the Superior Oil Company were equipped for pumping, that is, the concrete foundations laid and all surface machinery set, between July 17 and the middle of November of 1932. Had this work been started about November or December the probabilities are that, employing the same number of men, it would have taken almost twice the time and much greater expense to do the work. For example, in January and February of this year it was almost impossible on account of rain during these two months to drive to more than a few of these locations because of bad roads. In the case of these 28 wells, plans were made well in advance and due regard taken of the probable weather conditions that would prevail while the work was in progress.

During last December and January, a geared power unit was installed on a lease in the south end of the field. Normally this job would have been completed in less than 30 days but owing to the weather conditions that prevailed during these months the job took about 45 days. The greater part of this loss of time was due to rain, mud and impassable roads. Needless to say, the cost of construction on this job ran very much higher than if the installation had been made during good weather. On this job six pumping jacks were set at wells together with the necessary road lines and central power connections.

One of the most interesting installations in the field to date has recently been carried out on a well and is the first of its kind in the East Texas field. Although there are several wells that are being pumped from a back side crank of another well, there is none that has a take-off like this one. The interesting feature of the take-off from this well is that the rod line passes underneath the derrick floor, thus eliminating any obstacles that would be a hindrance or cause interruption to a crew working on the derrick floor. In addition, the arrangement allows the rod line to be near the ground and eliminates the need for a rocker post ahead of the knockoff post. Another interesting feature of this job is the 90-deg. swing from which two wells are being pulled; there is one rod line from the back side of the crank to the swing, thence a rod line from each end of the swing to two other wells. It is the intention to operate only one of the two wells on the swing at a time unless it becomes necessary to pump them both 24 hours a day, in which case three wells will be pumped from one unit. Because of having two wells on it, the swing has a heavy post and brace of much greater strength than that normally employed.

Several obstacles were encountered on this job that were overcome in an interesting manner. A road had to be crossed that later is to become a highway and it was required that the rod line be run under the road. To do this it was necessary to start a ditch some distance away from the road on each side so as to allow plenty of room for grading and widening when the highway is constructed. About 54 ft. of 10-in. pipe was laid in the ditch, the top of the pipe being about 2½ ft. below the crown of the road. As the well was quite close to the road it was necessary to use two hold-ups and two hold-downs on this crossing. To drain off the water that accumulates in the tunnel a drain was installed from the 10-in. pipe. This installation, which is on the Thrash lease of J. E. Mabee in the Joinerville area, was installed during very bad weather. In this instance the immediate necessity of putting these wells on the pump left no alternative than to forego any consideration of weather conditions so far as it concerned the installation of the equipment.

Where possible, installation of pumping equipment on the wells should be anticipated months ahead so that advantage can be taken of weather and road conditions that will result in a minimum installation cost. There is also the fact to consider that should wells stop flowing they can immediately be placed on the pump without delay. It is well known, of course, that to make any long-range prediction regarding many of the wells in the East Texas field would seem futile at this time. However, this should be all the more reason, in view of the uncertainty of the situation, why even more consideration than usual should be given to the problem of when to install equipment. An installation made during good weather will save many times the interest on the money necessary to make the installation ahead of time and unquestionably allows the contractor to make a much neater and more thorough job of installation.

Difficulties of Establishing Equities by Proration in the East Texas Field

By K. C. SCLATER

IT is not surprising that difficulties have been encountered in attempting to put into effect in the East Texas field a method of proration that is equitable. The whole purpose of proration is to allow each operator in the pool, which is assumed to be a common reservoir, to produce his well or property at such a rate that he will receive his just share of the oil, gas, and gas energy therein. As the pool is a common reservoir in which physical changes take place as the oil and gas are withdrawn, it is imperative that certain restrictions in producing the pool be observed by all operators to accomplish this end.

Difference in Well Spacing Too Great

Development of the East Texas field has been so rapid that the observance of practices that would result in the greatest ultimate recovery of oil from the field at the minimum cost to produce have been overlooked in the competitive haste to get wells down. The field has been developed with an almost total disregard of subsurface conditions or of how wells should be spaced. No attempt has been made to enforce a reasonable well-spacing program. Tracts as small as three acres or less adjoin those many times greater in extent. So, when the need for prorating the field arose many loopholes were found for attacking, on the plea of inequity, any proration method proposed. Under these conditions it early became evident that if acreage were to be part of a proration order it would have many belligerent opponents among the owners of wells on small tracts. Many of the small operators, opposing the acreage clause, argue that the inclusion of acreage in a proration order would virtually amount to confiscation of their properties at prevailing low crude prices because of the low ratable taking that it would allow them per well. They contend that not enough revenue would be obtained to pay the cost of operating their wells. The only proration order ever issued for the East Texas field including acreage was rescinded a few days after it was issued for fear it would be construed by the courts as confiscatory to penalize wells that were too closely spaced. The fact that drilling permits had been issued to drill on these small tracts was a strong point favoring the opposition of acreage considerations. Had a reasonable minimum well spacing been enforced from the beginning of development of the field, this difficulty would have been obviated. It has proved one of the greatest obstacles in reconciling equities in the field by means of proration.

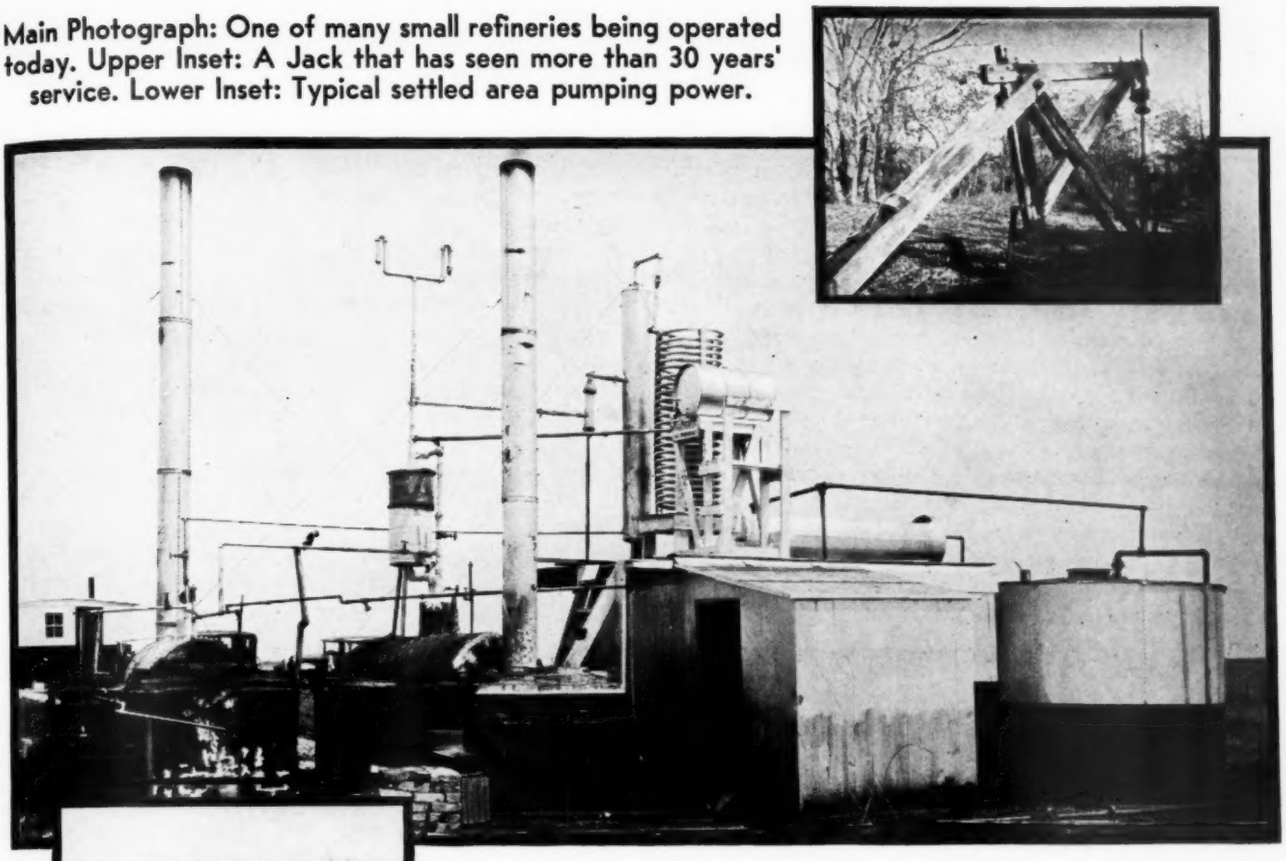
Since the development of the East Texas field, rapid progress has been made in analyzing reservoir conditions by direct measurements of bottom-hole pressure and temperature under both static and flow conditions. This information, when supplemented by oil and gas analyses of samples obtained from the bottom of the well under pressure, is found to have a valuable practical application to the study of physical changes that occur in the reservoir as the oil and gas are withdrawn. Bottom-hole pressure measurements of a well at various rates of flow provide a more accurate index of a well's potential than surface measurements, for they are not affected in value by the mechanical equipment in the well or by any artificial restrictions imposed on the well's flow. Another significant feature of the data obtained by these bottom-hole pressure flow tests is that they reflect the physical character of the sand, an important consideration in determining a well's ratable allowance. Lack of suitable instruments and the cost of making subsurface measurements has militated against their use by operators in the East Texas field. Many are unwilling to assume the added cost and increase the cost of well operation. Then again, there are many who are not yet ready to accept the data or conclusions derived from subsurface studies of this nature. As the field was developed without regard to well-spacing or subsurface considerations it was not to be expected that the field could be successfully prorated by any method that had some scientific basis. A compromise seems to have been effected by determining a well's potential by surface flow.

To use the potential thus determined as a measure of the value of a well or a property has no justification. Taken alone, the ability of a well to produce tells only half the story. For example, two adjoining leases with the same amount of acreage, sand thickness, porosity and saturation would be expected to have the same amount of oil. Should one lease have a sand of low permeability and the other a sand of high permeability, or in field parlance, one had a tight sand and the other a loose sand, great differences in their ability to produce would be observed by a potential test despite the fact that they both have similar oil reserves. Even though less oil might be recovered from the property with the tight sand the difference would not be at all in proportion to that showed by a potential test. It might be that in the East Texas field the differences in permeability are not so great as to bring about observable differences in reservoir pressure as the oil is withdrawn at the present relatively low rates of production. It remains to be seen, however, whether the differences in rates of production as established by potential tests are discriminatory or not. It will be one of those fortuitous happenings in nature if potentials are an indication of the oil reserves underlying a property in the East Texas field.

It is assumed that the bottom-hole conditions in the wells tested were uniform. The type of liner, how it is placed, and other factors bearing on the completion of the well must be taken into consideration. Where there has been the same degree of care in drilling and completing wells it is seldom that two wells are effected alike, so far as the rate at which the well will produce is concerned.

How the equity of the proration based on potential tests compares with the method based on sand thickness and other subsurface considerations is not known. It may, under the conditions that obtain in the East Texas field be as equitable as any other method that is practicable to apply at present; this remains to be seen.

Main Photograph: One of many small refineries being operated today. Upper Inset: A Jack that has seen more than 30 years' service. Lower Inset: Typical settled area pumping power.



Problems of Stripper Well Operation

By C. I. LAYTON
President, Layton Oil Company

FOR the past two years the problems of the stripper well operator have been many and complex. After going through the adjusting period following the severe price cuts of 1931, he had reduced his operating expenses and retrenched to the point where he was getting along fairly well, when out of a clear sky came a 50-cent price cut, all in the course of 30 days' time. That put him right back to where he was in 1931. Having already reduced his operating costs to the minimum, about the only thing left for him to do was to try to get his taxes reduced.

This was accomplished in eastern Kansas. A meeting was held at Chanute, at which the county clerks of all the eastern oil counties of Kansas met with the members of the Kansas Stripper Oil Well Association. Evidence was produced to show the actual yearly earning power of the average stripper oil well in eastern Kansas, with the result that the county clerks quickly recognized that to continue to impose more than a fair tax on the actual earnings the stripper wells would soon be taxed out of existence.

Under the new set-up, the wells are taxed at $165.00 each. Instead of the old ad valorem method of listing all material, equipment and production, and paying taxes according to the total valuation, the number of wells on each lease is simply listed and this number multiplied by $165.00; $8.25 per well is then deducted for the royalty interest, leaving a net tax valuation per well of $156.75. Gas wells are taxed at $90.00 each. Buildings, warehouse stock, drilling and pulling machines are listed separately. This new method is just as efficient as the old, eliminates about 90 per cent of the clerical work, and has reduced stripper well taxes about 30 per cent.

In Oklahoma the operators of stripper wells are not doing so well regarding taxes. They are confronted with the possibility of an additional tax on casinghead gas from the stripper wells, a doubling of the gross production tax, and also the placing on wells of an ad valorem tax of some sort. This would practically eliminate the stripper wells in Oklahoma, as it would mean, at the present price of crude, an assessment of about 25 per cent of gross income for taxes—a taxation burden greater than stripper wells can stand, and one much in excess of the present three per cent gross production tax.

Interesting facts being brought out by the depression in the stripper territory are the great number of wells and the large number of men employed that are seriously affected when stripper wells are hit by price cuts and proration. It is estimated that the wells in eastern Oklahoma and eastern Kansas average one-third of a barrel per well per day. It is also estimated that every 16 bbl. of crude produced in this territory supports one family of five. So the number of people affected by price cuts in the stripper fields is much larger than it is in areas of flush production where one man can take care of several hundred barrels of oil per day.

On January 18 of this year, the date when the last 25-cent cut in the price of crude in the Mid-Continent was declared, operators of stripper wells were left stunned, but for a short time only. Operators first thought that it would be a matter of only a few weeks until conditions would adjust themselves, and the crude price brought back, but in this they were mistaken. So they began to look around to observe and ascertain what the cause and effect were locally, and they found that fuel oil was selling at twice the price of 33-gravity crude. It was found that in areas within trucking distance of some of the larger cities, fuel oil purchasing companies were accepting deliveries of oil direct from field storage tanks, at a 30-cent premium over present market price. It was also observed that so far as local communities in the stripper well area were concerned gasoline was being consumed in about the same proportion and at the same price as usual. Kerosene and tractor distillate were selling as well as gasoline. In this many operators began to see a ray of sunlight through the dark clouds. Here they were selling crude to the pipe line companies for from 28 to 38 cents per barrel. By skimming off six or eight gallons of gasoline the crude would be reduced to about 26-gravity oil, which could be sold as fuel oil at 60 to 65 cents per barrel, and which, with the 24 to 32 cents for six or eight gallons of gasoline, brought a total price of 85 to 97 cents a barrel for the crude.

An initial investment of from $1000 to $5000 is made in a small skimming or cracking plant. Friends and neighbors of the operator form a ready market for the gasoline and distillate. Fuel oil has a ready sale, and the demand is becoming greater every day. These skimming plants of 100-bbl. to 250-bbl. capacity, are each operated with only two or three men, are usually constructed right on the lease and eliminate the necessity of a pipe line. All gasoline is sold at the plant, and the fuel oil is shipped by rail or truck. An accurate accounting is kept of all products made and sold, and *all* taxes are paid.

Economical rod and tubing pulling equipment, Layton Oil Co.

Ingenuity is essential if the small operator is to make a profit

At least ten such plants are in operation in Kansas today, and many others in northeastern Oklahoma. With a continuance of low crude prices, many more are likely to be built, and once in operation, their subsequent relinquishment may be difficult. One, or a dozen, of these small plants may not hurt the large refiners, but a thousand or more of them will. With a continuance of present conditions it may be only a matter of time until the small producer shall be placed in the peculiar position of selecting his own market. Refinery trucks may call at his lease for his crude, in competition with the present single pipe line market that now obtains, or if he did not care to do business with either of them, he could load his oil on a truck and haul it to some near-by refinery, after the same fashion a farmer does a load of wheat.

These small plants have none of the high charges that are necessary to the large refinery—no pipe line, no overhead, no sales organization, no trucking, and very little labor. It has been noticed in the localities where these plants are located that they follow the posted prices of the regular gasoline market, and that very little price cutting, if any, has resulted. In many cases, the business men of the community join with the producers to build the plant, the business men putting up the cash, and the producer the production. In this way the business men become boosters for the products of their respective plants. So long as a good satisfactory product is produced, many of these small plants may continue in business and hold their markets indefinitely without fear of serious competition.

From the very circumstances of the plight in which the operators of stripper wells found themselves, the large company cannot with justification condemn these small operators for following the course they have taken. It is certain that had the price of oil remained higher than 75 cents per barrel, very few, if any, of these plants would have been built; it has been a matter of self-preservation. A continuance of the prevailing low crude prices cannot but add to the number of the small plants that will be constructed and put in operation. A premium of 30 cents a barrel seems too tempting to be overlooked in times like these.

It might be well to say, in passing, that many producers think there is too wide a range in crude oil prices, and that the scope of the price territory called "Mid-Continent Field" is too great. It covers about one-fourth the area of the United States. California alone has more than 20 price structures.

Different price structures, set up in different parts of the country, would not only help to prevent and discourage the operation of the small skimming plants in the field as discussed here, but would also arouse the vital interest of the producer in the market situation, as it affected him, so that he would produce accordingly. As it is now, many producers are forced off the regular channels of a steady market by overproduction in the Oklahoma City and East Texas fields. Those who are in the heart of a good consuming market get less for their oil than the very oil from the field the overproduction of which has brought ruin to the whole petroleum industry. If Oklahoma City and East Texas had each had a price structure of its own, each could have been penalized for overproduction by drastic price cuts, and the producers in fields that were abiding by proration, and in no way responsible for the overproduction, could have gone on about their business, enjoying a reasonable profit and supplying a necessary product. It is proper to spank the boy that rocks the boat, especially when he deliberately succeeds in capsizing it.

With a further cut in the price of crude just announced on account of the high allowable in the new East Texas field order the stripper well operator has been placed in a precarious position. Many at this moment are not sure whether they will be able to weather the storm or go under. This is further evidence that unless each producing area recognizes the rights of other producing districts it should be penalized and made to suffer for its own folly.

Preventing Corrosion By Use of Cement-Lined Pipe

By WARREN L. BAKER

Satisfactory results have been obtained in handling salt water and hydrogen sulphide mixtures

REALIZATION that corrosion causes vast destruction, engineers in the petroleum industry consider its prevention a major engineering problem. It has engaged the entire attention of a corps of engineers of the petroleum industry during the past four or five years, during which much experimentation and research work have been done. Improved methods and products to decrease the effect of corrosive agents have been uncovered; but though substantial progress has been made and new light has been thrown on the problem of corrosion there still remains a dire need for better preventives.

In the course of constant study and endeavor to improve and prolong the life of pipe used under corrosive conditions, many engineers have been impressed with the results obtained from the use of ordinary cement-lined pipe. Careful investigation disclosed, however, that the original types of linings of this sort were deficient in several important particulars. In the first place the cements in use were relatively soluble due to their high lime content, and in the second place, the ordinary cement linings undergo excessive shrinkage during setting. This caused loose and cracked linings that were easily broken away from the pipe wall, with the consequent loss of their entire protective value.

Heretofore, cement-lined pipe has not been readily available. In fact, much of the cement-lined pipe in service was lined by local department crews during their spare time, using improvised methods and the natural cement at hand. In more recent years, linings have been prepared from Portland cement, either alone or with admixtures of natural cements or of sand.

In their efforts to develop a superior type of cement-lined pipe, manufacturers have conducted extensive research work on the composition of special cements intended primarily for corrosion-resistant pipe linings. One company has developed special curing methods that, together with the special chemical composition of the cement used, result in minimum shrinkage during setting. At the same time, mechanical ingenuity has devised greatly improved methods of introducing cement linings into the pipe.

When the concrete lining of a pipe has an unusually smooth interior facing, the flow of liquids under a given head is greater than for the unlined pipe of the same diameter, according to exhaustive tests. The best available data are as follows:

Discharge Coefficient (C) for Hazen & Williams formula:

Cement-lined pipe - - - - - -	C = 148
Wrought (welded) pipe - - -	C = 140
Cast-iron pipe - - - - - - -	C = 125

This discharge coefficient expresses the relative velocity of flow of water in pipe as influenced by the smoothness, all other factors, such as diameter and pressure, being equal. The initial volume of flow through new unlined iron or steel pipe is somewhat greater than that through new concrete-lined pipe of the same nominal size (but smaller inside diameter due to the lining); the above tests, however, were made with pipe of the same internal diameter.

Cement-lined pipe has been used in water lines for more than 100 years and has demonstrated its effectiveness in combating interior corrosion. As a matter of fact, until recent years this was practically the only recognized application.

Concrete exterior coatings have been applied in the petroleum industry in a few instances during the past two years and some interesting experiments have been conducted with cement-lined tubular goods. Experience over several years with Duroline, the trade name given the concrete-lined pipe of the National Tube Company, in a number of oil fields has shown pipes protected with cement linings to be satisfactorily resistant to salt water and fluids containing hydrogen sulphide.

A line of 6-in. pipe has been in service for about two and one-half years in a salt water disposal system near Luling, Texas. This line handles about 1000 bbl. per day of water containing a total of approximately 38,000 parts per million of sodium, magnesium, and calcium chlorides, and about 500 parts per million of hydrogen sulphide. The line is laid in low-lying country in a sandy soil, its position causing it to be filled with salt water at all times, regardless of the rate of flow. An inspection of this disposal system after 1½ years' service, in which alternate lengths of the pipe were lifted, showed no deterioration of the lining and that no tubercles had formed on the inside of the pipe.

Gathering lines of concrete-lined pipe were installed about four years ago near Casey, Illinois. These lines are still serviceable in spite of the fact that they are operating under highly corrosive conditions. These lines are also protected against exterior corrosion, in part by regular plastic coating, and in part by galvanizing.

In an East Texas oil refinery, 4-in. cement-lined pipe was in good condition after 14 months' service on the transfer line of a clay cooker. During this time 133 batches of fluid, each batch containing 10,600 gallons of a mixture consisting of clay, sulphates of iron and aluminum, and dilute sulphuric acid of four to seven per cent free acidity, at a temperature of 160 to 180 deg. fahr., were transferred through the line.

Improvements in the methods of manufacturing cement-lined pipe, together with the success of tests conducted in the petroleum industry, have created much interest in its possibilities for combating internal corrosion in pipe lines. Experience gained and results obtained in the extended use of cement-lined pipe will be followed with interest because of the importance of the corrosion problem to refiners and transporters of natural gas, gasoline and crude oil.

Modern Pipestill Heater Design

Article II—Radiation in Pipestills

By W. L. NELSON
Professor of Petroleum Refining
University of Tulsa

PIPESTILLS in which all the heat is transferred by radiation are not practical because too much surface is required, but there has been a universal tendency to absorb more and more heat in the radiant section of the pipestill. Certain modern stills absorb 70 to 80 per cent of the heat available in the fuel by radiation. The reason for this change in design is the mild or low *rate* of heat input that is possible with the large radiation-section type of still. While such a pipestill may cost more than an ordinary still the increase in cost will be quickly repaid by the greater life of the refractory walls and the pipestill tubes. Furthermore, for certain operations such as the heating of treated lubricating oil stocks and cracking, which require a low rate of heat absorption, the large radiant-section type of still or the recirculation still is necessary.

In designing the details of a pipestill or designing a still for special service, a knowledge of the distribution of radiation in different parts of the radiant section is important.

Usually only two rows of tubes are used in the radiant section. The reason for only two rows is apparent if the relative amount of radiation falling on each of the two rows is considered. If the radiation absorbed by the first row is called 100 per cent, the radiation on other rows is approximately as follows: First row of tubes, 100 per cent; second row of tubes, 43 per cent; third row of tubes, 12 per cent; fourth row of tubes, negligible.

Thus if a pipestill is operating with a radiant absorption factor R of 0.5 (oil fuel—25 per cent excess air) about 26,000 B.t.u. per hour per sq. ft. of projected area is absorbed. But in the first row of two rows of tubes the rate of absorption is $2 \times 26000 \times 100/143 = 36500$ B.t.u., while in the second row only 15,500 B.t.u. is absorbed. For heating sensitive stocks the flow through the tubes is occasionally arranged so that the oil enters through the first row of tubes and leaves through the tubes nearest the walls.

The first rows of tubes in the convection section may also absorb heat by radiation from the flame. In addition, some radiation occurs from the hot gas to the convection tubes, but this radiation may be best considered as a part of the convection transfer coefficient. The radiation that penetrates into the convection section from the radiant section, if the convection tubes are not screened by superheater tubes or by brickwork, is about as follows: First row of convection tubes, 100 per cent; second row of convection tubes, 56 per cent; third row of convection tubes, 19 per cent; fourth row of convection tubes, 4 per cent; fifth row of convection tubes, 1.5 per cent.

These first few tubes must withstand a more severe rate of heat absorption than any other tubes in the still. These tubes absorb more heat by convection than any of the other convection tubes and in addition, they absorb almost as much heat by radiation as do the radiant section tubes. Thus in the aforementioned still, if the gases leave the radiant section at about 1600 deg. fahr. and the convection coefficient of heat transfer is about six B.t.u. per hour per sq. ft. of outside tube surface (note Table I) the total rate of heat absorption will be:

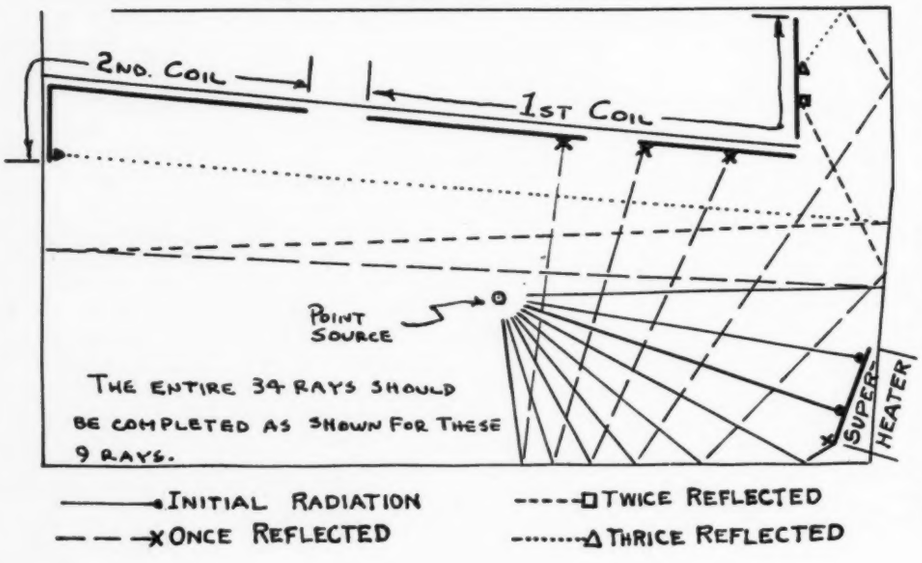
Basis: 1 sq. ft. of outside surface; oil inside tube at 450 deg. fahr. Tube diameter 4-in. O.D.
By pure convection 1 (1600 — 450) 6 = 6900 B.t.u. per hour. The length of tube required to give 1 sq. ft. of outside area is 0.95 ft. Projected area of this length of tube is 0.315 sq. ft.
By radiation $0.315 \times 36500 = 11400$ B.t.u. per hour.
Total absorption = 18300 B.t.u. per hour.

The use of radiant absorption rates on the basis of projected area and convection rates on outside area is confusing. In the above example the radiant absorption of 11,400 B.t.u. based on the outside diameter is exactly equivalent to an absorption rate of 36,500 B.t.u. based on the projected area of the first row of radiant tubes or to an average radiant absorption rate of 26,000 B.t.u. per sq. ft. of projected area (see previous example).

Thus the first row of convection tubes absorbs about 60 per cent more heat than the most severely heated radiant tube. For this reason the first rows of the convection section are often designed with the same diameter as the radiant tubes, or in other words, for higher oil velocities. Steam superheater tubes are often placed between the radiant and convection sections to protect the first convection tubes. In a superheater the high rate of absorption is desirable providing the superheater is constructed of an alloy material that can withstand high temperature oxidation.

The rate of radiant absorption varies at different parts of the radiant section. In ordinary stills the exact distribution of radiation is not important but when (1) heating sensitive stocks such as treated lubricating oils, (2) heating to very high temperatures as in cracking stills, and (3) heating two different stocks in separate coils in the same radiant section, the rate of heat absorption in different parts of the furnace box becomes very important. Data on several stills have been reported that indicated

Figure 1—Distribution of Radiation



radiation rates that varied by 400 per cent in different parts of the radiant section. While the fundamental theories of radiation are well understood, the constants by which these theories can be applied to furnaces heated by a flame are not available. The following method yields approximate data on the variation of radiant absorption. While the method is termed as approximate, nevertheless it has been checked against four different sets of plant data on three stills and the computed results were within five per cent of the actual results.

Radiation proceeds in all directions from point sources within the flame. It proceeds in straight lines and either strikes a cold tube surface and is absorbed or it strikes a refractory wall. Upon striking a wall, the radiation first heats the wall but after the wall reaches a temperature higher than that of the tubes, the wall itself begins to radiate. At the high temperature existing in pipestill walls, the walls act as reflectors so that radiation falling upon the wall is reflected so that the angle of reflection equals the angle of incidence. Each time the radiation is reflected it becomes less intense, due first to the heat lost through the walls by conduction and, secondly, because the intervening gas is heated. The intensity of reflected radiation, considering the heat liberated as unity, is approximately as follows: Initial radiation, 0.75; once reflected, 0.68; twice reflected, 0.61; thrice reflected, 0.54.

The relative amount of radiation absorbed by any surface may be determined graphically by drawing the walls, tubes and flame to scale and drawing rays of radiation from a point source in the flame as indicated in Fig. 1.

Total heat in fuel $= 34 \times 1 = 34$ heat units.

	Heat Units Absorbed by First Coil	Second Coil	Superheater
Initial radiation (No. rays) $\times$ 0.75	6.0	2.25	1.5
Once reflected (No. rays) $\times$ 0.68	5.45	1.36	0.68
Twice reflected (No. rays) $\times$ 0.61	1.83	0.61	0.61
Thrice reflected (No. rays) $\times$ 0.54	1.62	0.00	1.08
Total heat units for each coil	14.9	4.22	3.87
Surface in each coil (sq. ft.)	88	71	23
Relative absorption rate heat units/surface	0.1695	0.0595	0.168

$$\text{The average absorption rate} = \frac{14.9+4.22+3.87}{88+71+23} = 0.126.$$

At an average absorption rate of 11,000 B.t.u. per hr. per sq. ft. of projected area the absorption rates in the several coils are:

First coil $= 11000 \times 0.1695/0.126 = 14800$ B.t.u.
Second coil $= 11000 \times 0.0595/0.126 = 5100$ B.t.u.
Superheater $= 11000 \times 0.168/0.126 = 14750$ B.t.u.

The accuracy of the method is improved by repeating the above operation for several planes and using several point sources of radiation.

TABLE I

Vel. ft./sec.	Temperature Deg. Fahr.	2-in. O.D.	4-in. O.D.	6-in. O.D.
10	800	4.6	5.4	5.9
10	1400	6.1	6.9	7.4
15	800	5.6	6.6	7.4
15	1400	7.0	8.0	8.7

TABLE II

SERVICE	Radiant Absorption Rate	Radiation Factor—25% Excess Air—no Preheat or Recirculation	Usual Oil Velocity ft./sec. (60 Deg. Fahr.)
Crude Oil Topping	31,000	.48	3
Reduced Crude—Vacuum	25,500	.51	4
Cracking—outlet in convection	25,500	.51	5
Cracking—outlet in radiant	17,000	.57	6
Pressure Distillate rerun	28,000	.50	4
Light Lub.—Oil rerun	20,000	.55	5
Heavy Lub.—Oil rerun	17,000	.57	7

TABLE III
Effect of Flue Gas Recirculation at a Constant Absorption Rate

Flue Gas Recirculation	Fraction of Heat Absorbed in Radiant Section	Relative Quantity of Surface
0.0	0.52	1.000
0.3	0.42	0.806
0.5	0.36	0.695
0.8	0.31	0.595
1.0	0.26	.05
1.5	0.20	0.386
2.0	0.14	0.27

TABLE IV
Effect of Flue Gas Recirculation at a Constant Amount of Radiant Surface

Flue Gas Recirculation	Fraction of Heat Absorbed in Radiant Section	Absorption Rate—B.t.u.
0.0	0.52	17,000
0.3	0.44	14,400
0.5	0.40	13,100
0.8	0.36	11,800
1.0	0.335	10,950
1.5	0.29	9,500
2.0	0.25	8,200

Observed coefficients of heat transfer in the convection section are usually 60 per cent to 250 per cent higher than the pure convection coefficients given in Fig. 2, Article 1[1] of this series. The reason for this apparent discrepancy is mainly due to the following factors: (1) Radiation from the hot flue gas; (2) radiation from the hot walls of the convection section.

Monrad[2] has made a study of these factors. The first of these will be designated as hrg, or the coefficient of heat transfer from the gas by radiation. As an approximation, the value of this gas radiation coefficient may be found by the following relation:

$$\text{hrg} = 0.0025T - 0.05$$

in which T is the average temperature in deg. fahr. of the flue gas. More exact methods of computing this factor are given in the aforementioned reference.

The second factor, the wall effect, ranges in magnitude between 6 per cent and 15 per cent of the sum of the pure convection and the radiation coefficients hc and hrg.

$$\text{Per cent wall effect} = \frac{\text{hrb} \times \text{Aw} \times 100}{(\text{hc} + \text{hrg} + \text{hrb})\ \text{At}} \text{ in which:}$$

hrb = radiation coefficient from walls $= 0.00688p(T/100)^3$
p = emissivity of wall surface—usually about 0.95.
T = absolute temperature (zero fahr.) of tube.
hc = pure convection coefficient.
hrg = gas radiation coefficient.

Subscripts w and t refer to the wall and tube respectively. The complete coefficient of heat transfer in the convection section is computed from the above items as follows:

$$h = [(100 + \%\ \text{wall effect})/100]\ (hc + hrg)$$

In addition the first convection tubes receive radiation directly from the furnace but this additional heat may be better considered as a part of the radiant section.

Actual transfer coefficients for the convection section computed by the above methods are presented in Table I.

Recent designed stills have been made using the absorption rates shown in Table II. The allowable absorption rates are not affected by air preheat or recirculation of flue gas but the radiation factor is greatly affected. Table III indicates the effect of flue gas recirculation on the radiation factor under the following conditions: (1) A constant absorption rate of 17,000 B.t.u.; (2) a 12-deg. A.P.I. fuel having a G. of 18 lb. air per lb. of fuel; (3) 25 per cent excess air. Table IV shows the change of absorption rate with different recirculations but in a single still in which the radiant surface is not changed.

[1] *Petroleum Engineer*, p. 21, April, 1933. [2] Ind. Eng. Ch., 24:505, May, 1932.

» » » Lowering Production Costs

Construction of all-metal power houses to reduce fire hazard is explained in detail

THE drastic slash in the price of Bradford District Pennsylvania grade crude from $4.35 per bbl. in 1929 to a present low of $1.47 has compelled the use of varied methods and expedients to reduce the loss in producing oil at the low prices that have prevailed since that year. What follows refers particularly to properties operated under the five-spot water pressure plan of producing oil in the Bradford district.

Operating conditions and expenses have been closely scrutinized in order to determine when and how reductions in the cost of producing oil could be effected. As is usually the case, a combining of work commenced with the elimination of that which was not considered absolutely essential to the production of oil. One of the first divisions examined was that covering the water supply to the water intake wells.

Operating Economies

At the inception of the prevailing method of flooding the Bradford sand through 2-in. tubing with a packer cemented in place above the sand, a water meter was connected to each water intake well and read daily, a record being made of the quantity of water the well had taken in the previous 24 hours. This work required one or more meter readers on each property. One of the first changes made was to transfer this work to the pumper who was pumping the oil wells in the five-spot blocks. Daily readings were changed to weekly with very satisfactory results; some of the meters would get out of order and not record the full volume of water going into the well, but this was a minor consideration in view of the saving in labor effected.

The next expense item that attracted attention was the fuel bill for gas purchased to operate the powers. On some of the properties this item had reached $800 per month. It was decided to put in a vacuum pump and recover the gas from the stock tanks. This was done and sufficient gas was obtained to operate the leases without recourse to purchased gas. A very sensitive vacuum regulator was placed on the outlet of each gas line from the stock tanks to prevent pulling a vacuum of more than 0.2 in. of mercury on the tanks. Vacuum and pressure relief valves, made from 2-in. clapper style check valves, were placed on each tank to prevent damage to tanks in case the regulator failed to function. Springs of the proper tension were inserted in the check valve to permit the valve to open should the vacuum or pressure on the tank exceed 0.2 in. of mercury.

Later on, another possible source of gas was observed at the individual 20-bbl, 4 ft. by 5 ft. wooden tanks set at each oil well to gauge its daily production of oil and water. To procure this gas a trap consisting of a piece of 6¼-in. casing 6 ft. long, closed at one end by welding a plate in place, and a 2-in. collar welded in this end plate for the gas connection was used. A sketch of this trap is shown in Fig. 1. A 2-in. collar was also welded in the side of the casing 18 in. from the end that was closed. A 2-in. opening, with a depth of 3 in. and a 1-in. radius was cut in the side at the open end. This gas trap was placed in the wooden tank, closed end up, and the gas piped from the top through the casinghead of the well, where any oil carried over by the gas dropped out. The oil and water passed out through the 2-in. by 3-in. opening at the bottom of the casing into the wooden tank. Sufficient oil always remained in the tank to prevent the vacuum (1 in. of mercury) from pulling the oil out of the gas trap and permitting air to enter the gas line. A gas meter placed on such a gas trap, registered 350 cu. ft. during the time the well produced 5 bbl. of oil and 30 bbl. of water. When it became necessary to purchase individual well tanks, a change to gas-tight steel tanks was made and the gas taken directly from the tank. Gas measured from this type of tank showed 550 cu. ft. during the period when approximately the same quantity of oil and water was produced. This additional gas was obtained as a result of the longer time the oil was under vacuum in the steel tanks. It was found that even though a well was pumping all water, gas was being produced at the same time. A series of measurements are being taken on one property to determine the volume of gas produced per barrel of water when the oil production is 1 bbl. or less and the water production 20 bbl. or more per day.

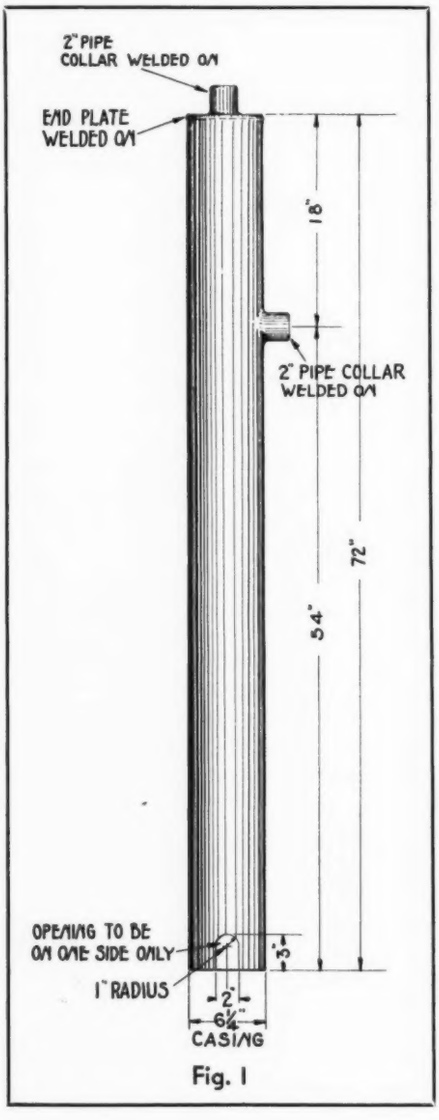


Fig. 1

Working barrels of the plunger-type equipped with balls and seats made of alloy steel are used almost exclusively on large water-flood projects. These working barrels have reduced the pulling of wells to a nominal figure. On one

In The Bradford Field « « « «

By

H. K. DOUGHERTY and JESSE G. GIBSON

General Superintendent Chief Engineer

The Sloan & Zook Company, Bradford, Pa.

property, where a pulling crew was always two or three wells behind, there have been instances lately where not a well has been pulled during a month's period.

In addition to providing a treated water for use in pressuring, the use of filters to filter the water used in flooding has had several indirect benefits, one of which is the longer time water meters remain in service before cleaning and repairing are required. The use of water meters tested to 2000-lb. pressure has reduced the number of replacements previously found necessary due to the bursting of the lighter case of the earlier type meter.

Tractors formerly were a source of expense but a schedule has been established for the greasing and cleaning of them every day and a thorough checking-over once a week. A monthly form is sent to every foreman showing the cost of gasoline, oil and repairs on every tractor operated by the company, and the tractor drivers watch for these reports with great interest to learn how their particular tractor stands in relation to others. The cost of tractor operation has now dropped to a reasonable figure.

Back-pressuring in oil wells by maintaining a column of fluid in the well has been practiced with a fair measure of success in some parts of the Bradford field in reducing the quantity of water pumped, while in other parts of the field the results have been nil. Back-pressuring is most effective in sands containing a more permeable section that allows the water to pass through rapidly. It is on this permeable section that the fluid column acts in restricting the flow of water, while still allowing the water pressure to act on the tighter sections of sand.

The smaller volume of water now necessary to pump under back-pressure control has permitted one power to be shut down 16 hours per day where formerly it was necessary to pump 24 hours per day to keep the water down. This has reduced materially the operating expense on this particular property through the elimination of a night pumper and also a consequent decrease in repairs.

Pipe Frame Power Houses

One of the most important steps taken looking toward a long-time reduction of operating costs was the elimination of wood construction from all buildings erected on our producing properties. From 1931 to 1932 our company had three disastrous power house fires that caused considerable incon-

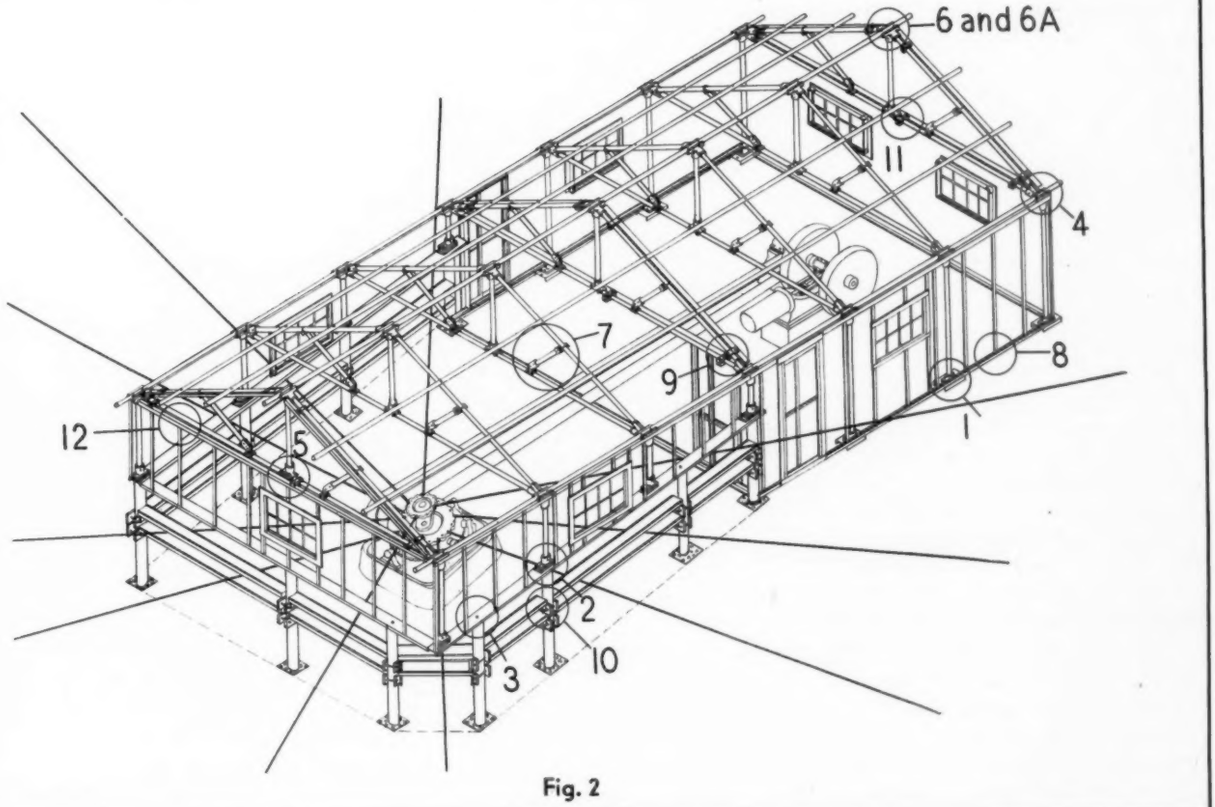


Fig. 2

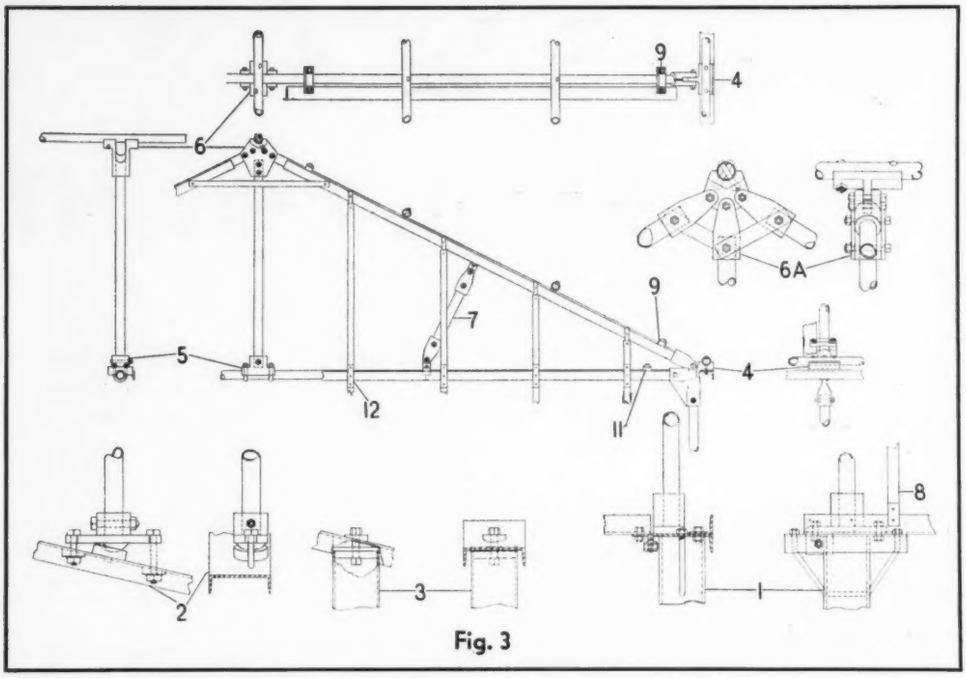


Fig. 3

venience and lost production until the power houses were rebuilt. It takes a long time to absorb a fire loss on a property, as those who have had the experience can testify. How to eliminate this risk through the construction of steel buildings, without involving too much expense was given much thought. The idea was finally conceived that the frames of such buildings could be constructed from rejected 2-in. pipe. Our engineering department was consulted on the subject and the following details of construction will show how well the idea has worked out.

The 2-in. pipe used in the frame is material rejected for any purpose where pressure is required and has no monetary value as junk, but for the frame of a building is as good as new pipe. The construction is as follows: Where buildings are more than a full joint of pipe in length, the ridge pole, purlins and plate pipes run the full length of the building, as if each were a continuous piece, by driving steel pins about 10 in. long into the ends of the pipe to form the joint. The joists are handled in the same fashion if the building is more than a joint of pipe wide.

The general scheme of forming the junction points of all pipes, such as the pipe rafters joining the ridge pole, the pipe columns, rafters and joists joining at the plate, is executed by the use of castings. These castings can be made up in different designs but after some experimentation the following conclusions were reached: First, that cast iron is a very economical metal for the above purpose as the castings are clean and ready for use without any machine work whatever; second, that bolting the castings to the different members of the frame is highly successful, and has the advantage of permitting ease of dismantling and moving to another location. This system has been carried out throughout the building scheme and applies to the structural steel and corrugated iron fabrication as well, as will be explained later.

Each truss consists of the following members: two rafters, the joist, a center brace and two side braces, one each side of the center brace located at the most advantageous point for bracing. The space between trusses should not exceed ten feet. This works out well on either one-third or one-quarter pitch roofs of buildings up to 30 ft. wide. The columns are of 2-in. pipe, one end being secured in the corner truss casting, and the other end in a footer casting bolted to the foundation footer. The foundation footer is also of metal construction, as it has been our experience with concrete footers that have passed through a fire, especially if water was played on the building during the fire, that generally they all have to be replaced.

The footer for both engine and power house consists of lengths of old 5⅝-in. casing, which is another material that has no monetary value in the northwestern Pennsylvania fields. Quantities of it are available on all properties. An 8-in. channel of structural iron, 16 ft. long, is bolted on top of one end of the 5⅝-in. casing by a U-bolt, for the engine house. Holes about 24 in. square for footer foundations are dug to a depth sufficient to reach "hard pan." All holes are located at the position where column footers are to be centered. The 5⅝-in. footers are then lowered into these holes, leveled up to the corrected height and set vertically with a transit, then concreted in position.

The top of footers for the engine house end are set at such a height that the structural sill, which is bolted to the channel iron on top of footer, is slightly above ground level. The footers for the power house are placed at convenient positions in the power house so they miss the rod lines, thus eliminating all angle swings in the rod lines from power to wells. The power is always located and grouted in before the power house is built. This method assures correct alignment of all component parts regardless of whether the power is set with the driving cranks or eccentrics in a level position or at an angle. Two 8-in. channels weighing 11.5 lb. per ft., placed on top of the power house footer pipes, run the entire length of the power house, one on each side, and rest on flat-shouldered castings that are driven into the ends of the 5⅝-in. footer pipes to the shoulder. A hole through the center of this casting admits a ⅞-in. machine bolt, which runs through the 8-in. channel and the footer pipe and ties them together. If the power is set on an angle, the channel irons are set on the same angle by inserting a wedge-shaped casting between the inside of the web of the channel and the flat casting in the end of the 5⅝-in. footer pipes. The wedge-shaped casting, which has a hole through the center for the ⅞-in. machine bolt, has one face at the same angle as that at which the power is set. The travel board assembly that is carried between the footer pipes of the power house end of the building will be explained later in this article.

For power houses that are to accommodate a power set on an angle, the footer castings for the columns of the trusses in the power house end are made on the ball-and-socket principle. This allows the columns to stand vertical no matter at what angle the channel irons on the footers are set. If the power is set with cranks or eccentrics level, the same column footer castings are used as in the engine house end. The sill

NATIONAL PUMPING EQUIPMENT

TYPE G-100 GEARED POWER

National's Type G-100 Geared Power, with the Type D-130 Jack, makes possible the economy of central power house operation for pumping deep wells that ordinarily would require standard rigs and individual engines.

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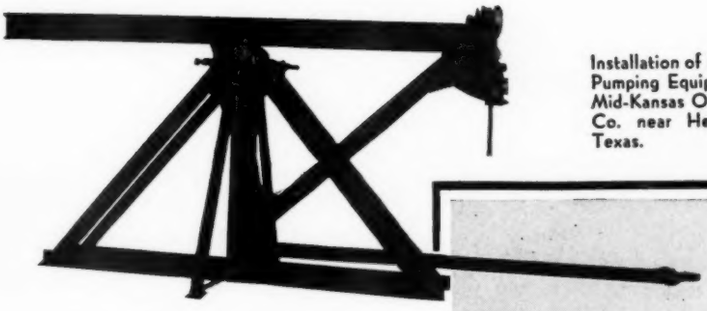
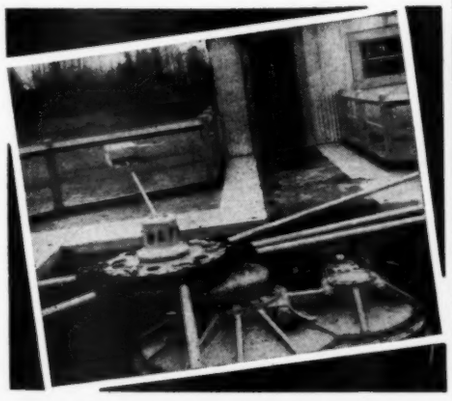
National Type D-130 Jacks are of all-steel, arc-welded construction, entirely self-contained and self-supporting, with excess strength and extreme rigidity.

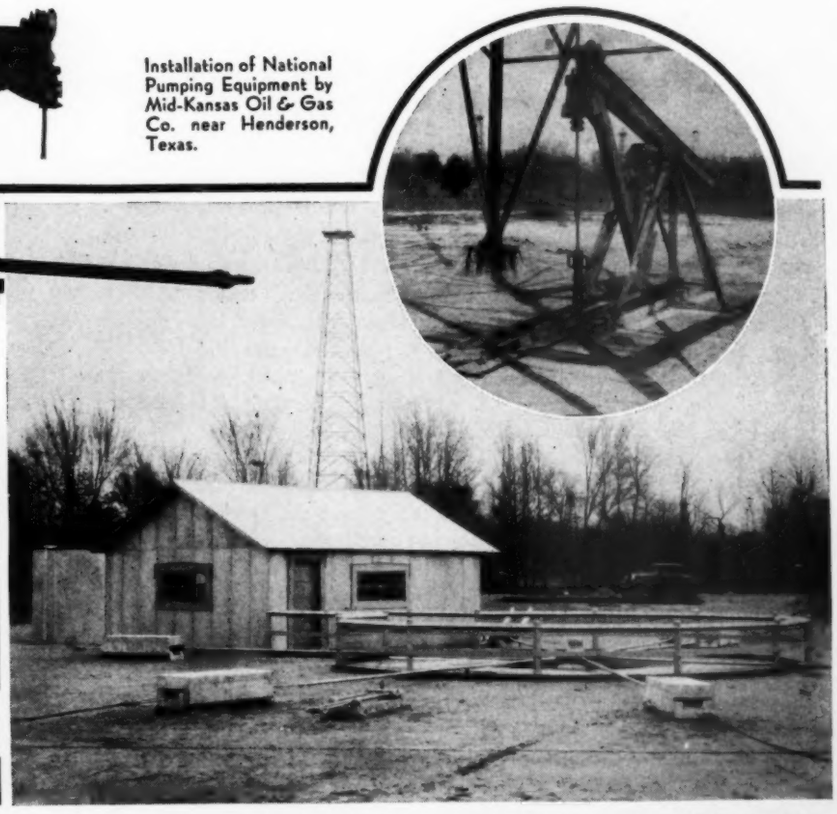
National Pumping Equipment provides economical installation, efficient operation, and long, continuous, dependable service.

Descriptive literature free upon request.



TYPE D-130 JACK





Installation of National Pumping Equipment by Mid-Kansas Oil & Gas Co. near Henderson, Texas.

THE NATIONAL SUPPLY COMPANIES

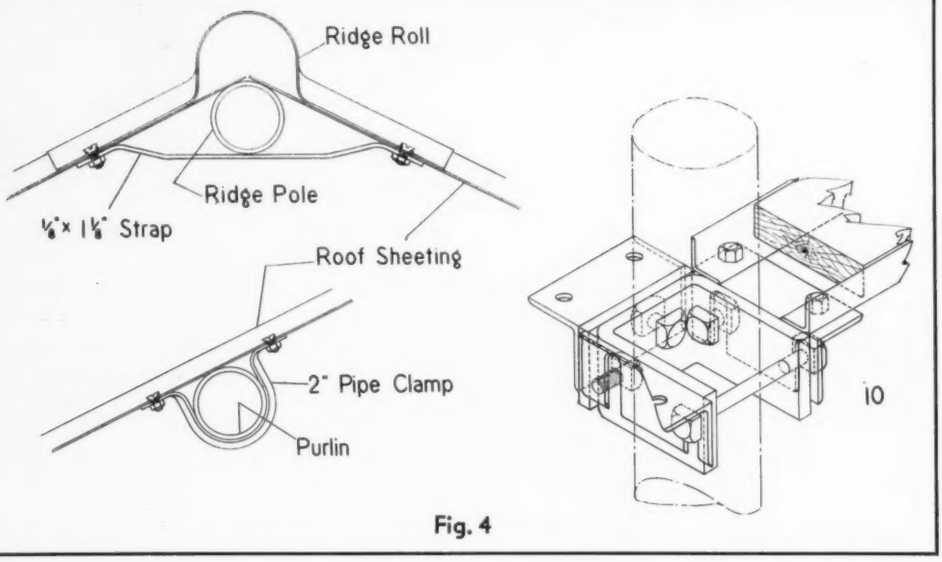


Fig. 4

for the power house end of building is clamped to the footer pipes just above the running board assemblies by U-bolts. The size of this sill is 2 in. by 2 in. by 3/16 in. angle iron, one lip of which is drilled or punched to receive the studding and rivets the corrugated iron.

The fabrication is as follows: the corrugated roof iron is secured to the ridge pole, purlins and plate pipes by clamps and screws, the screws being of brass of the machine screw variety. The under-side of the head of these screws is tapered and closes off the hole punched in the corrugated iron to receive it, thus forming a waterproof joint. The plates, sills and gable trim are of 2½ in. by 2½ in. by ¼ in. structural iron, and the studding 1½ in. by ⅛ in. structural iron, of the lightest weight per ft. procurable.

The plate is secured in position by bolts through the corner truss castings and the plate pipes of the frame and the structural plates. The gable trim is secured at desirable points by clamp castings that clamp around the rafters and joist pipes, and in turn to the gable trim of structural iron just mentioned. The 2½-in. lip of plate and gable trim is punched or drilled at 2-ft. intervals with 5/16-in. holes to receive the studding. Other holes of the same size are located between the 2-ft. spacings for fastening the corrugated iron in place.

The sills are bolted to the above-mentioned footers and are drilled or punched, with same spacing as plates, through the 2½-in. lip for securing the lower end of the corrugated iron and studding. The studding is secured to the lips of plate and sill iron members by strap-iron clips 1½ in. wide by ⅛ in. thick. Four 5/16-in. holes are drilled or punched about ¾ in. apart over the length of these clips, which should be about 4 in. long. Holes in the studding, at the corresponding distance of holes in lips and clips, are punched or drilled and machine screws with nuts entered through clips. The lips and clips secure studding in position. The studding must be punched or drilled with 5/16-in. holes about every foot the entire length for securing lapped joints of corrugated iron to studding. The corrugated iron is fastened to the studding in all cases with split copper rivets having ½ in. diameter head, 3/16 in diameter shank, and 1½ in. long.

The structural iron sub-structure for carrying the travel boards is made up of side rails of 2 in. by 2 in. by 3/16 in. angles, and 6 in. by ½ in. by 8 in. flat iron spacers, the flat iron being bolted to the inside of the angles. The lips of the angles act as anchorage for the 2 in. by 8 in. hardwood running boards for the travel rods. By using U-bolts and slotted clips at the ends of running board assembly, the U-bolts securing the clips to the footer pipes in the power house, close adjustment can be made between travel rods and running boards in any direction.

Doors and windows are left until the last in the specifications. The windows are of the sliding type, two-sash of six lights each, these lights being about 8¾ in. by 12 in. size. The jambs for windows are made of 2½ in. by 2½ in. by ¼ in. angle iron bolted together with angle clips, using flat-head machine screws to avoid interference between sash and jamb in sliding sash. The stops are of ¾ in. by ⅜ in. flat iron bolted to the jambs to hold the sash in position. The windows can be located at any desired position by the aid of the studding and the holes in the angles of the window jambs for fastening corrugated iron to windows.

The door frame proper is made of 2 in. by 2 in. by 3/16 in. angle iron bolted by angle clips and machine screws at the corners. Regular studding is used to fabricate the corrugated iron to the doors, the studding being secured to the frame same as to sills and plates. Diagonal strain rods, with turnbuckles of small size, are used to keep the doors in perfect rectangular shape. The door jambs are made of 2½ in. by 2½ in. by ¼ in. angle iron secured at corners with angle clips and bolts. The hinges for the doors must be heavy and three used to each door. These doors were built—both single and double—at prices that compare favorably with those used in wood construction.

Numbered key drawings (see illustration, Figs. 2, 3 and 4) prepared by the engineering department, show the different building details and their location. Each metal part carries an aluminum band with same number as detail drawing on it. This greatly assists in the assembling of the building.

From the foregoing description it can readily be seen that these buildings can be dismantled at any time and rebuilt without the loss of anything in the way of material except the foundation footers. All the machinery that is required to handle all details of these buildings are a forge, a power hacksaw, drill press, electric drill and a press, if holes in structural iron are punched.

Cost records kept reveal that buildings of this type can be built at a price that compares favorably with those of wood construction, and after careful study, this company definitely decided to build no more power houses of wood construction in the future. Eight metal buildings have been erected over a period of one year and have proven that they meet all demands.

Development Costs

Development costs per acre are being reduced by wider spacing. In 1928, the distance between water and oil wells was usually 175 ft. or less, today it is 250 ft. in some cases and is still steadily becoming greater. All in all, it has been a constant struggle to match the receding price of oil with a corresponding reduction in operating cost, with the odds at present in favor of the price of oil.

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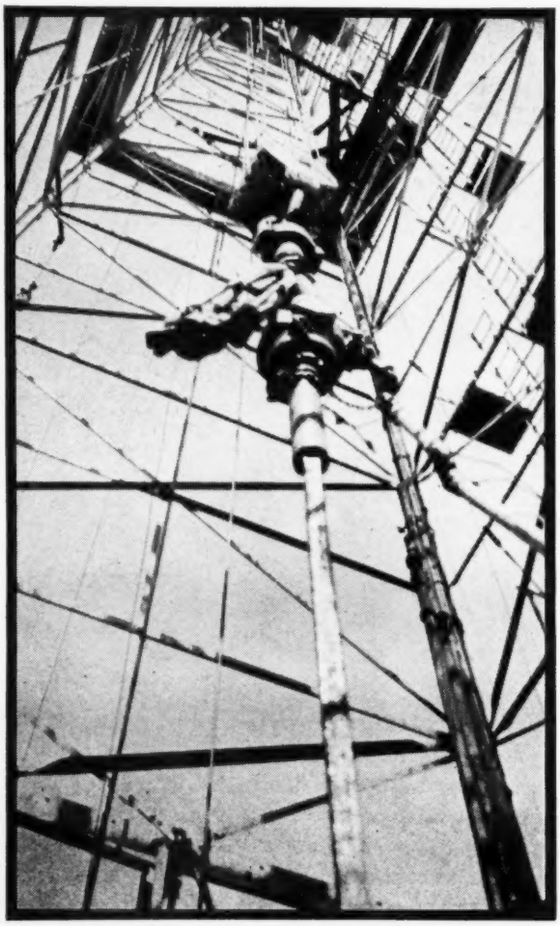
Kettleman Hills Well Now Holds Depth Record

Weight of 7-in. casing in well is 155 tons. Ultimate depth may exceed 11,000 feet

By WALLACE A. SAWDON
Petroleum Engineer

THE breaking of a drilling depth record is news; but the methods and equipment used, together with the conditions encountered and handicaps overcome, are probably more important. The limelight is naturally thrown on any well that passes the existing world's record for depth; and the achievement, when accompanied by a diligent endeavor to prove a field or the extension of a producing area, is of marked interest to the entire petroleum industry. The Lillis & Welch well No. 1, located in Section 24-21-16 — the most northerly location on the North Dome of Kettleman Hills, Calif. — came into the spotlight on April 23, 1933, when it passed the record depth of 10,585 ft., held until then by Penn Mex Fuel Company's well, Jardin 35, Alamo, Vera Cruz, Mexico.

Known as the McAdams well, this, the deepest well in the world today, is being drilled by the North Kettleman Oil and Gas Company, under the supervision of Ed McAdams, its president and general manager. J. J. Campbell, the superintendent, and L. L. Jackson, assistant superintendent, are in direct charge of the drilling. Unless production is picked up before then, the well will probably be drilled to a depth greater than 11,000 feet.



Looking up at some of the equipment that helped put the well down

The record-breaking well was spudded in on April 12, 1932. The hole is comparatively straight and, it is interesting to note, is being drilled according to McAdams' method of carrying little weight on the bit, rotating fast and using a reamer above the tool joint. The drill pipe is equipped with Bettis protectors and a Siever reamer is placed about 40 ft. above the bit. Care in maintaining a straight hole in this instance has been well justified, for it no doubt has contributed to the success that has been obtained in running the casing and keeping the hole in condition.

Drilling to 10,225 ft. was accomplished with Reed and Zublin bits, the latter being employed to drill through certain sticky formations as they were encountered. One of the new 5⅝-in. 3-cone type Hughes bits was installed at 10,225 ft. in tough brown shale. An average footage of 45 ft. per bit with an average run of 33 hours was obtained. During the entire time the bit is on bottom it is found to stay to gauge.

Most of the coring was done below 7000 ft. with a Krum-Brainard core barrel. A total of 82 cores had been taken before the record depth was reached; and before the well is finished the total number of cores will probably reach 100.

Four-inch special drill pipe was used for the 5⅝-in. hole down to about 7000 feet. A string of 3-in. National drill pipe was then installed and it is interesting to note that this 3-in. string is one that had been previously used. Though only six fishing jobs have been encountered on the well to date, not one second trip has been necessary to recover the fish. These jobs were caused by twist-offs; one at 9900 ft., leaving four joints in the hole, and another at 10,100 ft., leaving six joints.

An 82-lb. mud was used to 10,200 ft., with the pressure sometimes running as high as 1400 lb. per sq. inch. At that point new mud was introduced with Colox as an admixture. This was necessary, since the brown shale would not mix with the fluid and would not come up with the returns without the aid of an admixture. The weight of the new fluid was kept at 90 lb. per gallon, the pump pressure was decreased to 1225 lb. per sq. in. and the pump speed increased to ten strokes per minute.

Trouble in getting the cuttings out actually started at about 9000 ft., due to the floating shale in the fluid; no inconvenience due to gas or water was encountered however, as the weight of the fluid then being used was sufficient to

With the *Compliments* of Colox Manufacturers ... Authoritative Treatise on *Better* Drilling Fluids

Replete with valuable reference tables and completely discussing the application of amorphous Iron Oxide, the new Colox Bulletin will be of interest to you. It is the most complete report and discussion of drilling fluid material, and was prepared by engineers of C. K. Williams & Co., of Calif. Ltd., and Geo. S. Mepham & Co., exclusive licensees.

This Bulletin discusses the properties of Colox and the advantages of its principal constituent — Iron Oxide. It presents a carefully developed graph showing the relative advantages of colloidal iron oxide, and muds made up of different clays. It also embodies a photo-micrograph, production views and a large number of tables for use in computing the amount of dry solids to be used in obtaining a certain weight in a well of any dimension. By referring to the tables the driller can quickly calculate the cubic content of mud within the well, weights of drilling mud when clay is added, how much Colox to add to obtain a certain weight, method of calculating volume; relation between specific gravity, mud weights and pressure head.

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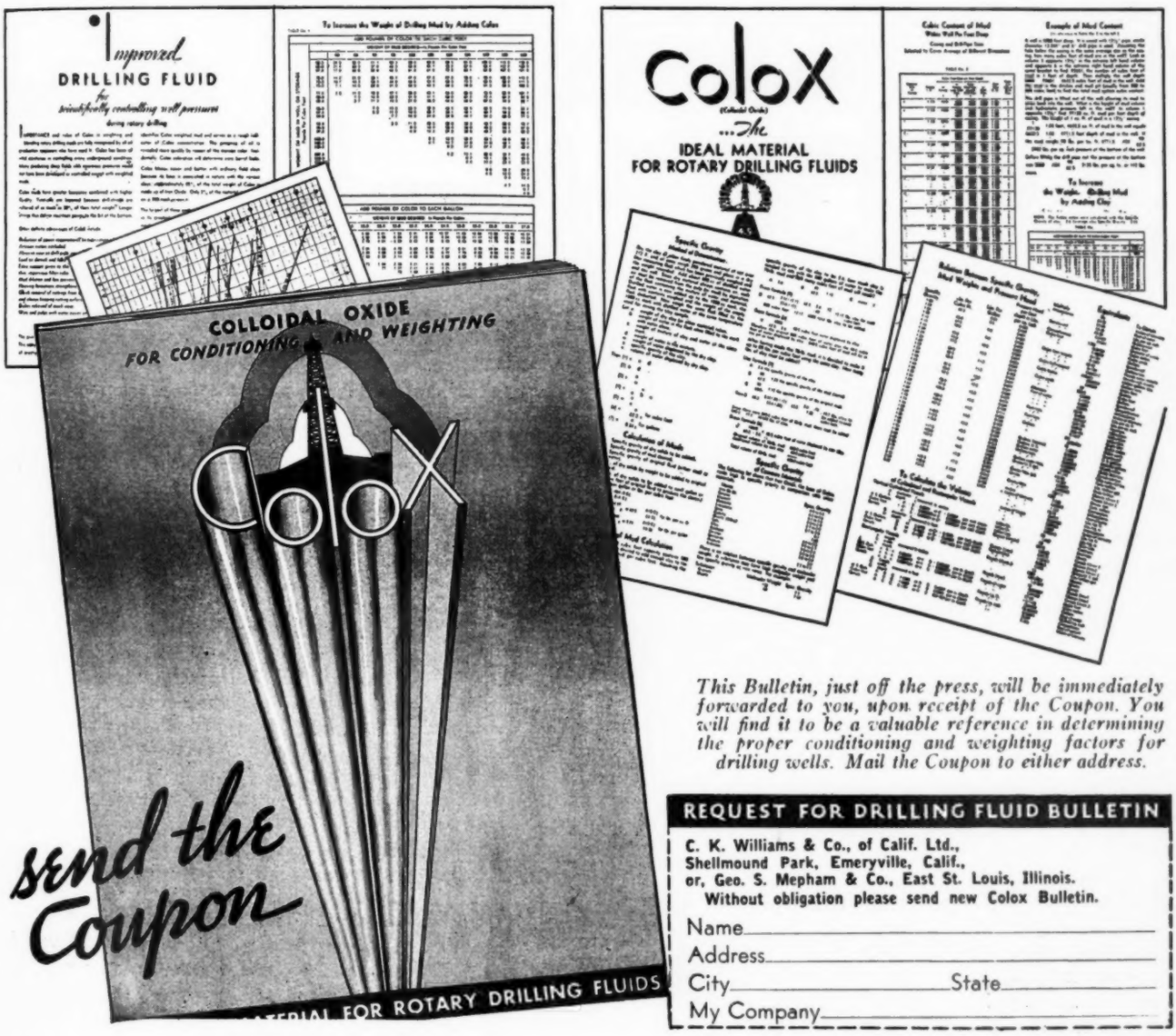

This Bulletin, just off the press, will be immediately forwarded to you, upon receipt of the Coupon. You will find it to be a valuable reference in determining the proper conditioning and weighting factors for drilling wells. Mail the Coupon to either address.

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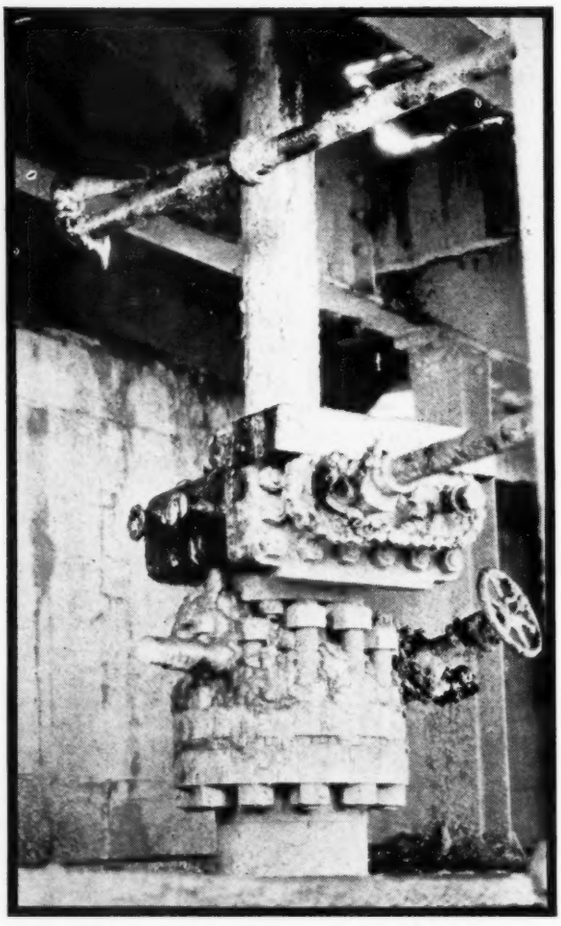
keep back any flow. The heavy flow of water similar to that found in the Kettleman Hills wells at about 5500 ft. or deeper was plainly noticed at about 7000 ft. in the McAdams well.

Mud circulation is adequately handled by two 7¾-in. by 14-in. by 14-in. Acme pumps and screened with a Lemco vibrating screen. Varco slush pump valves, piston rods, slips and liners are used on these pumps. Drilling fluid is controlled with a Martin-Decker mud pump gauge.

Casing programs and the safe landing and cementing of casing are important factors that must be given a great deal of thought and consideration in the drilling of extremely deep wells. In the case of the McAdams well, a depth considerably greater than that of the other deep wells in the Kettleman Hills field was known to be necessary and the casing program was thus laid out to provide for drilling to a depth greater than 10,000 feet. The possibility of mechanical trouble in running the casing also had to be reduced to a minimum, especially in the long 7-in. string, which also established a world's record for length casing string of that size. The weight or pull on the hoisting equipment was reduced considerably by floating in the casing, which was done with Baker cement float shoes on 18⅝-in. and 11¾-in. strings and by a Baker cement float collar and a Baker cement float shoe on the 7-in. casing. The entire internal construction of the floating equipment was, of course, non-metallic and consisted of cement and Bakelite, which were easily drilled up and circulated out of the hole.



This photograph is unique, being one of a very few taken in a rig cellar. It shows the modern construction and control equipment on the McAdams well

According to McAdams, one of the chief reasons for using the float plugs was to displace the fluid in the hole so that circulation could be maintained while the casing was being run. Keeping in mind the character of the formations and that there was almost 3000 ft. of open hole, it was deemed especially important in the success of running a long string of 7-in. casing. Good condition of the hole preparatory to the drilling or coring operations after casing is set is highly advantageous. Casing equipment that will assure the best condition is also essential at the great depth now being drilled. It is strict attention to these details that contributes in no small part to the absence of trouble and the successful completion of deep wells.

Grade D, A.P.I., casing was used and the first string run was Western Pipe & Steel 18⅝-in. pipe, which was cemented at 1078 feet. The next string was Jones & Laughlin 11¾-in. pipe, which was cemented at 6710 feet. While not quite so long as the record for this size pipe, it is interesting to note that this string was run in in 17 hours and 15 minutes.

The 7-in. string, besides being the record length for this size casing, presents other points of interest. It is Jones & Laughlin pipe, the lower 3500 ft. being 36-lb. A. P. I. grade D, and the upper 6145 ft. being 30-lb. A.P.I. grade D casing, making a total weight of 310,350 lb. for the complete 7-in. string. It was run to 9200 ft. in 18 hours; and from that point on to 9645 ft. it was carefully washed in. Another eight hours were taken to circulate the pipe in this last 445 feet. Special couplings having 10 threads per inch, with ⅜-in. taper for a distance of 4½ in., were used on the 7-in. casing. After the string of casing was cemented it was swabbed down to 7500 ft. and found on testing to be absolutely tight.

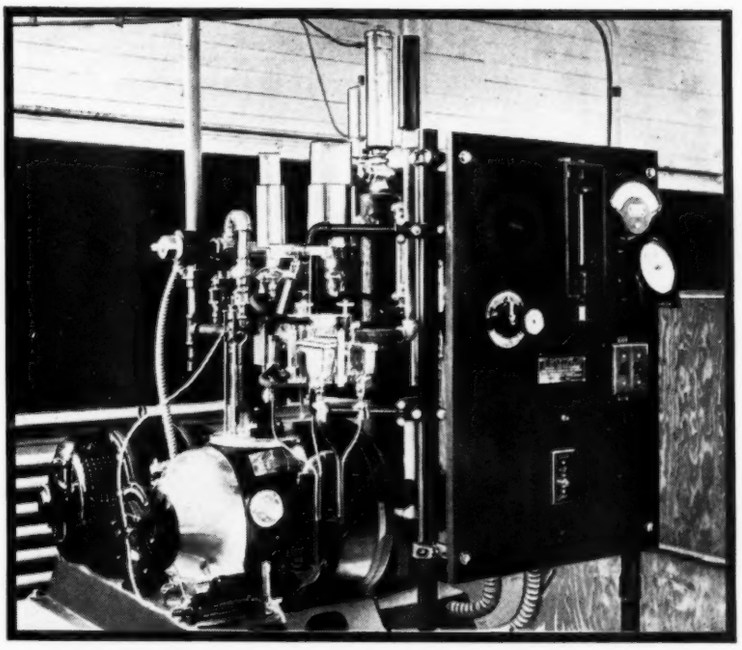
The three strings of casing were cemented by the Pacific Oil Well Cementing Company and every job was successful the first time. On the 7-in. string, 450 sacks of cement were pumped in, about 350 passing out of the casing and around behind the pipe. When a pressure of 1750 lb. was built up the pumps were stopped, as it was felt that a better job would be obtained by not pumping the cement too long under high pressure when it was moving too slowly.

When cementing commenced, a pressure of 600 lb. per sq. in. was required to circulate from the bottom. The pressure began building up when the cement started around the casing; this was probably due to the tight hole, which had necessitated circulating in the last 24 joints of pipe when it was run. The cement left in the pipe, however, was hard all the way to the bottom and the water shut-off test, made with a Johnson formation tester, showed the job to be good, with the cement extending around the casing for a distance of at least 1500 ft. above the shoe.

At the present drilling depth, 10,835 ft., it takes an average of three hours to pull out and a little more than two hours to run in with the 123 stands of drill pipe.

The well is equipped with an Ideco 136-ft. steel derrick of standard construction with Emsco reinforcement. Emsco drawworks, table, rotary chain, swivel and hook are in use with a Link-Belt chain on the drawworks. Both Thermoid and Asbestos brake linings have been in use. The rig equipment also includes a Baash-Ross kelly, a Hamer steel hose, a Hill & Foster automatic cathead and Martin-Decker weight indicator. The power equipment at the well consists of a twin 12-in. by 12-in. Ajax steam engine, four Lucey 90-hp. and one Broderick 85-hp. boiler, the steam being superheated to 600 deg. fahr. by a Foster-Wheeler superheater with boiler feed water treated with Permutit water softener. Other surface equipment includes a Regan 5-sheave crown block and traveling block, a 1⅛-in. Black wire line, Byron-Jackson tongs, weldless links and elevator, a Regan 6000-lb. type casinghead, and a Shaffer control gate valve.

As will be observed, no special surface equipment is being used on the well; some of it, indeed, has been used on other wells, demonstrating that, under normal drilling conditions, present equipment is capable of meeting the drilling requirements that the greatest depths now being penetrated demand. This assumes, of course, that good drilling practice must be followed and that due advantage be taken of the equipment designs that have been developed to meet deep hole conditions.



Series 30-B knock-testing engine at the School of Mechanical Engineering, University of Oklahoma

THE MECHANICS OF DETONATION

How Grade of Fuel and Engine Design Enter as Influencing Factors

By H. V. BECK
Assistant Professor, Mechanical Engineering, University of Oklahoma

EVERYONE associated with the the automotive and petroleum industries is showing increased interest in what takes place in an engine cylinder when it "knocks." This interest is not casual, it is of vital importance, for the public is becoming "anti-knock conscious." The average motorist, regardless of his pretentions, is more interested in performance and roadability than in any other factor, including economy. It is the impromptu race which starts at the stop-light that molds the opinions of the people who buy gasoline and automobiles. A premium motor fuel in a high-compression engine combines this flashy performance with an appreciable increase in economy. The inherent high efficiency of the high-compression engine, together with the greater power output, makes it technically and popularly more desirable.

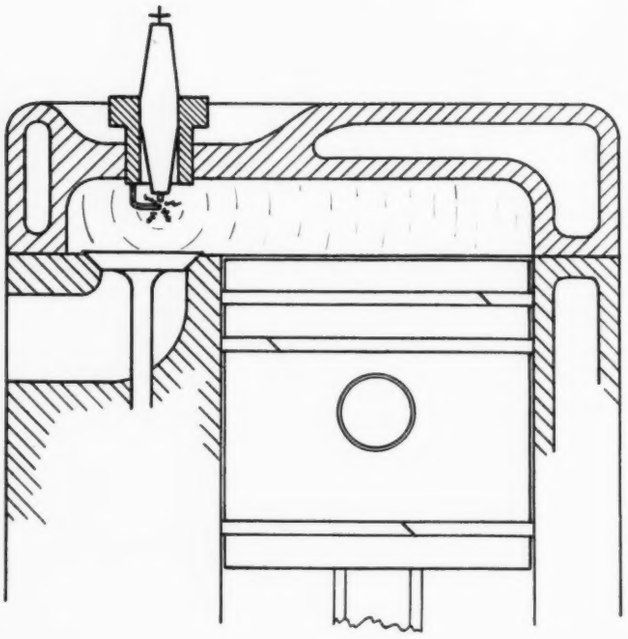
Most engineers are in general familiar with knocking or detonation: the condition that limits the high-compression engine. This condition varies with several factors, spark setting, engine speed, rate of power output and combustion chamber temperature. There is also considerable variation with the use of different anti-knock grades of motor fuels. Some fuels, because of their chemical composition, tend to resist detonation. Experience has taught us that an engine with badly carboned cylinders will knock more than a clean one. This association has led many to speak of detonation as "carbon knock." That the carbon in itself does not produce the knock is demonstrated by the production of the very same knock in a carbon-free engine having a high compression ratio and using an inferior fuel.

The solution of any such problem requires a theoretical analysis and a knowledge of the conditions effecting the process. It seems best, therefore, to start with a theoretical attack, using the generally accepted theory of detonation. When a gaseous mixture is suddenly compressed there is a tendency for the temperature to rise. This fact is used to explain the nature of detonation. Fig. 1 illustrates a simple combustion chamber with the piston near top dead-center at the end of the compression stroke. When ignition occurs the mixture of gasoline and air does not explode in the strict sense of the word but starts to burn smoothly, starting from the spark plug and progressing toward the far end of the combustion chamber. This burning occurs very rapidly, yet it requires a definite amount of time before the combustion is complete. The cylinder pressure increases due to this gradual liberation of heat, simultaneously compressing the yet unburned charge in the far end of the chamber. A rise in temperature accompanies this pressure rise of the unburned charge. If this temperature of the unburned charge increases beyond the auto-ignition point, the mixture will start to burn instantly over its entire mass. This instantaneous burning over the entire mass is in reality an explosion. The sudden high-pressure wave, thereby produced, strikes the cylinder wall with terrific impact and causes an audible knock. The kinetic energy due to the impact of this high pressure wave is dissipated as heat to the cylinder walls instead of doing useful work, and therefore the temperature of the cylinder walls is increased

and the efficiency of the engine is correspondingly decreased. Since temperature is the factor that originally caused the condition, it is obvious that the increased cylinder wall temperature due to detonation would work a vicious cycle, causing detonation to build up until conditions are stabilized by the increased rate of heat dissipation to the cooling water.

Instead of using the type of cylinder head shown in Fig. 1, a head of the same clearance volume will be considered, but a different shape. This head is illustrated in Fig. 2. The same set of operating conditions is assumed to exist. Obviously, in this style of combustion chamber, the tail-end charge is forced into a region where there is a large amount of surface compared with the volume occupied. This increased surface-volume ratio allows the heat of compression to be radiated so fast that the temperature of auto ignition is not reached. Detonation consequently does not occur. At this point it might also be said that the use of aluminum heads tends to suppress detonation, since the heat conductivity of aluminum

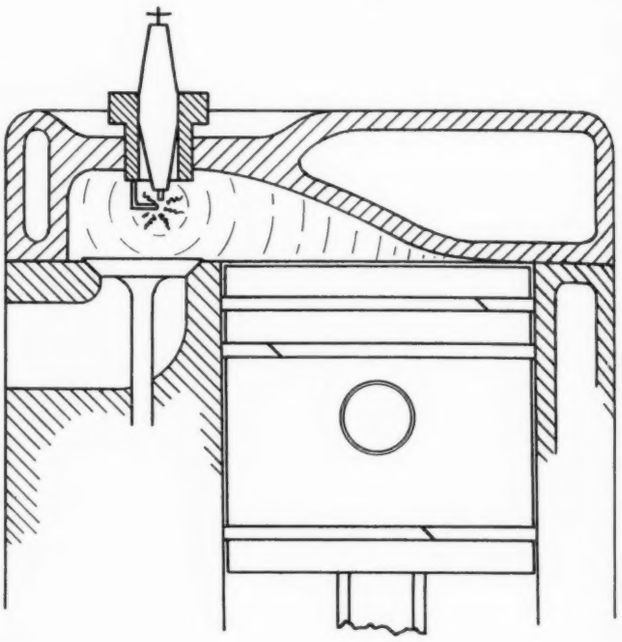
Figure 1



is greater than that of cast iron. Carbon deposits would produce just the opposite effect for the carbon insulates the gas from the walls and decreases the rate of heat dissipation. From this it can be seen that with proper cylinder head design the same fuel can be used in a higher compression engine without detonation.

The effect of spark advance or retard on detonation can best be visualized if one will consider that the burning is not instantaneous and that time allowed for the combustion to take place is very small. For an engine operating at 2000 r.p.m. the time required for 10 deg. of crank travel is 0.000833 seconds. If the combustion takes place so that the tail-end charge is compressed into a minimum volume, and consequently to a greater pressure and temperature, the condition of auto-ignition will be reached sooner and detonation will be aggravated. It can be seen that if the spark is advanced to such a degree that the burning wave strikes the far end of the cylinder when the piston is at top dead-center the above condition will be met and detonation will be most severe. If this condition is corrected by retarding the spark instead of changing the fuel, overheating, loss of power, and similar results of a late spark will be evidenced. These undesirable characteristics would destroy all the intended benefits for which the high-compression engine was built. This ignition lag also accounts for the need for a greater spark advance at

Figure 2



high speeds than low speeds. The time required for burning being constant, a greater degree of crank travel must be allowed.

The determinations for the degree of detonation of different fuels may be tested in several different test engines built specifically for the purpose. The engines most generally used are the Ethyl Gasoline Corporation's knock-testing engines and those developed by the Co-operative Fuels Research Committee. These test engines are all fundamentally the same. A single-cylinder engine with a very high compression ratio operates with conditions as nearly constant as possible. The degree of detonation is measured for different fuels with identical operating conditions.

At the University of Oklahoma considerable work has been done by the School of Mechanical Engineering in testing anti-knock properties of auto and Diesel fuels and experimentation with different knock suppressors. The gasolines being tested on a Series 30-B knock-testing engine developed by the Ethyl Gasoline Corporation and the Diesel fuel testing on a special test engine.

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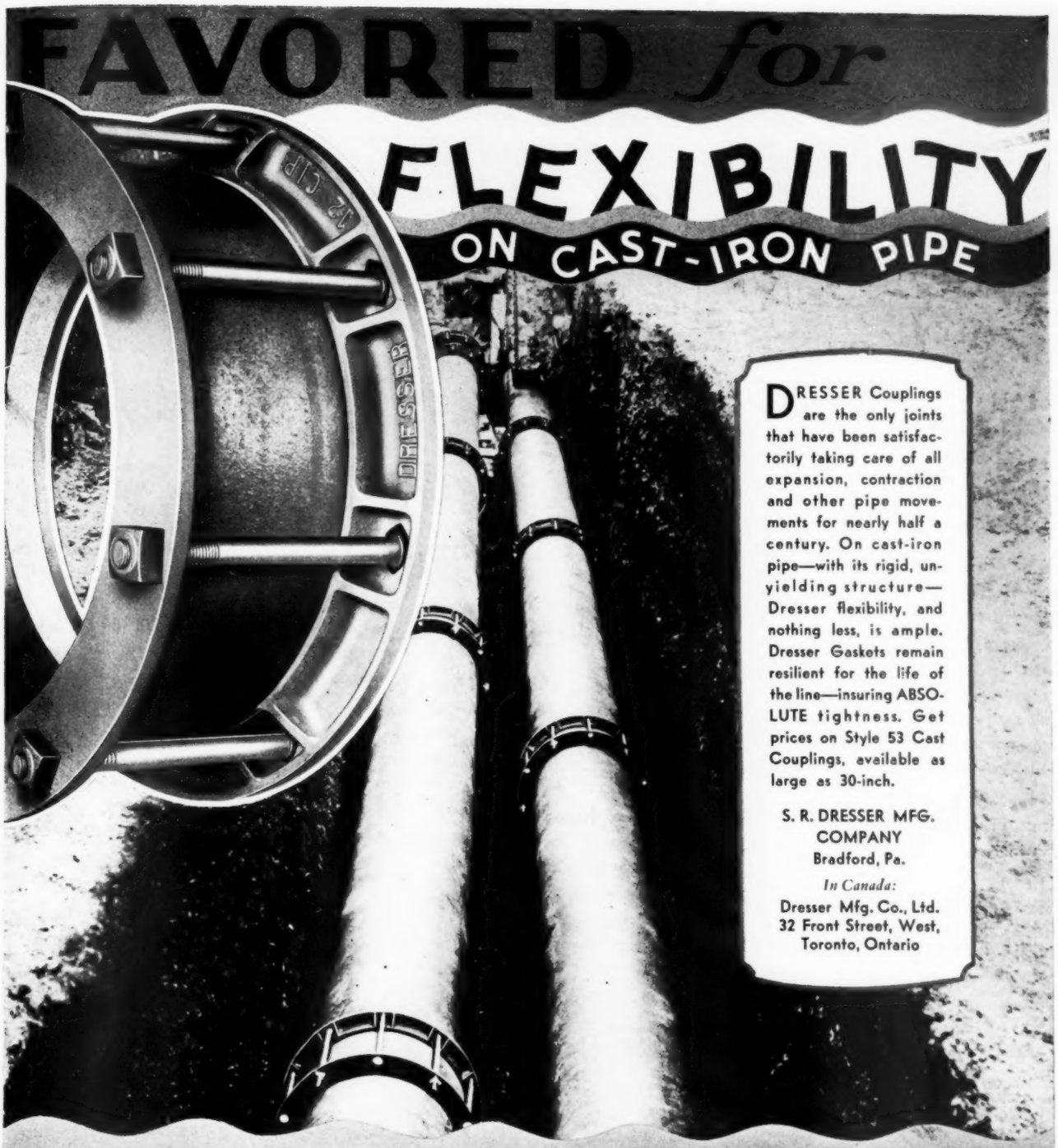

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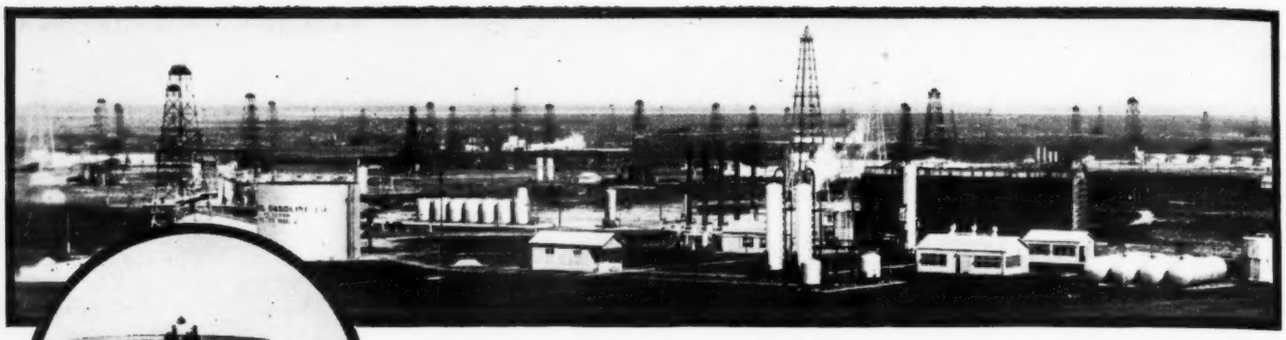


Big Lake natural gasoline plant operating on well pressure gas. Water storage tank at the left

Storage tank at electric-driven pump station

Water Supply and

By KENNETH S. RITCHIE Consulting Engineer

WATER for diverse uses in the Big Lake oil field, Reagan County, Texas, is obtained from several sources and by various methods. There are two principal areas from which water is obtained, one on the south side of the field and the other on the north side. Although the waters from these two areas are chemically different, neither is satisfactory for drinking purposes. Practically all the drinking water is shipped in by tank cars from Alpine, a small town in the Davis Mountain country, about 150 miles to the west.

Increased demands for water have occurred from time to time with the development of the shallow pay zones during the last seven or eight years. Also with the discovery of the 8500-ft. pay four years ago and the consequent enlargement of the natural gasoline plants and increased number of rotary drilling rigs used in the development of this deep pay. Even today, despite the increased number of water wells, there are times when the water for camp uses is practically cut off in order to supply a maximum to the rotary rigs.

The problem in this field is to obtain an adequate supply of water economically. A brief description of the pumping equipment used on the water wells will give the reader some idea of the ways in which the various operators have met the problem.

On the south side of the field, the underlying water strata are approximately 400 ft. below the surface, and these had been the principal source of water up until 1930, when the supply of water on the north side was developed. Most of the water wells are pumped from gas-engine-driven central powers. Each well produces on the average 200 bbl. of water daily. For a time an air-lift operated well at one of the gasoline plants averaged 1800 bbl. every 24 hours from four water-bearing strata between 360 ft. and 515 ft., including the principal stratum at 400 feet. Later a system of gas-driven steam heads was installed to provide additional water for another one of the gasoline plants. About 550 bbl. every 24 hours on the average are obtained through a 4-in. working barrel.

A typical analysis of the south side well water is given in Table I. The hardness given here is slightly low as the hardness frequently has been nearer 60 grains per U.S. gal. during the dry years. A large zeolite water softener installation treats all the water for household purposes in one large camp of more than 1000 population. In the other large camp in the field the water is used untreated. The lime-soda process has been found the most economical for softening this water for use in boilers.

The supply of water on the north side was first developed in 1930, when a test well indicated a more prolific source of supply and a water more suitable for gasoline plant uses than the old supply. A glance at the analysis given in Table

TABLE I

Typical Analyses of Well Water and Treated Water, Big Lake Oil Field, Texas

	Well Water		Treated Water (Northside)	
Incrusting or Soap-Consuming Solids:	Southside (Grains)	Northside (U.S.gal.)	Zeolite (Grains)	Lime-Soda (U.S.gal.)
Calcium Carbonate (Lime) $CaCO_3$	12.40	12.92	0.80	1.80
Calcium Sulphate (Gypsum) $CaSO_4$	15.78	5.37	.....	.....
Magnesium Carbonate $MgCO_3$	.....	.....	1.06	1.23
Magnesium Sulphate (Epsom Salt) $MgSO_4$	26.45	22.31	.....	.....
Silica SiO_2	1.40	0.60	.....	.....
Iron & Aluminum Oxides	0.37	0.15	.....	.....
TOTAL	56.40	41.35	1.86	3.03
Corrosive & Soap-Consuming Solids:				
Calcium Chloride $CaCl_2$	.....	.....	.....	.....
Magnesium Chloride $MgCl_2$	.....	.....	.....	.....
TOTAL	.....	.....	.....	.....
Non-Incrusting, Non-Soap-Consuming Solids:				
Sodium Carbonate (Soda Ash) Na_2CO_3	.....	.....	10.11	0.77
Sodium Sulphate (Glaubers Salt) Na_2SO_4	32.20	24.50	56.80	50.97
Sodium Chloride (Common Salt) NaCl	13.70	9.89	10.40	7.40
Sodium Nitrate $NaNO_3$	.....	.....	.....	.....
TOTAL	45.90	34.39	77.31	59.14
Summary:				
Total Dissolved Solids	102.30	75.74	79.17	62.17
Total Hardness in terms of $CaCO_3$	46.05	35.42	2.06	3.27
Alkalinity in terms of $CaCO_3$	12.40	12.00	11.60	4.00
Iron & Organic Matter	0.9 p.p.m.	.....	Considerable	.....
Suspended Matter	5.0 "	0.39	..... Trace	Ca ppt.
Iron in Sediment	.....	0.19	.....	.....
Iron in Filtered Water	.....	Trace	.....	.....
Dissolved Gases: Free CO_2	.....	0.60—2.40	0.40	.....
Half-Bound CO_2	.....	5.68	.....	.....

I shows this to be a softer water. The water-bearing strata were found from 250 ft. to 300 ft. below the surface. Automatic electric motor-driven deep well turbines were installed. With this equipment each well is capable of supplying 6500 bbl. of water every 24 hours. The accompanying illustrations show the wells, the storage tank at the water station and the house for the electric motor-driven centrifugal pump used to transfer water through two miles of 6-in. line to the large steel storage tank at the gasoline plant.

The principal operating expense for this installation is electric power. Labor expense, except for cleaning out, repair and maintenance, is very low because only part of the time

d Water Treating in Big Lake Field

of one man is required daily at the water station, the remainder of his working time being spent at the gasoline plant.

Another operator in this field procures water from these same strata with an installation quite different from the one just described. Each well is equipped with a 35-hp. Reid gas-engine-driven Worthington deep well turbine pump that produces about 1700 bbl. of water daily. The principal operating expense is for labor because three men divide the 24-hr. tour of each day's operation equally among them. Fuel gas is free except for the depreciation charge on the gas line. Hence, with cleaning out, repair and maintenance work being about the same, lifting costs per barrel for the two installations compare very favorably with each other.

Treating Methods, Results and Costs

The experience gained in treating the north side water at one of the gasoline plants, where both the zeolite and lime-soda water softener treatment are in use, provides a very good comparison for the two methods of water softening.

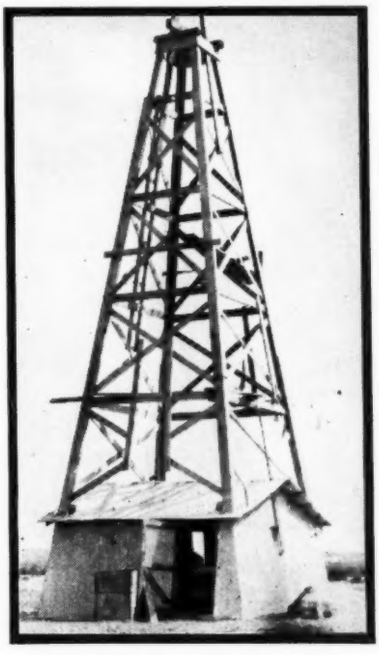
The zeolite system was used first. Reference to the analysis of the north side well water, Table I, shows that this water is superior to that on the south side, having less hardness and fewer total solids. It has an appreciable amount of finely suspended matter and of dissolved gases, which experience eventually proved to be undesirable for the zeolite process. Unlike the hot lime-soda process, the zeolite softener does not remove the dissolved gases (largely carbon dioxide) from the water before it enters the boilers. Part of the suspended matter gradually clogged up the filter bed, interfering with its efficiency, and part was carried on into the boilers. This formed a very fine reddish deposit, apparently iron oxide, which combined with the release of the dissolved gases in the boilers and eventually made it necessary to retube them. As can be imagined, this deposit seriously affected the steaming capacity of the boilers by slowing up their rate of evaporation.

An examination of the analysis in Table I shows that the zeolite treated water had a total hardness of 2.0 grains per U.S. gal. but its alkalinity in terms of calcium carbonate was practically unchanged from the 12.0 grains per U.S. gal. in the untreated water; there was also reported considerable suspended matter as iron and organic matter and an appreciable amount of dissolved gases. Experiments with boiling the zeolite-treated water with steam before it entered the boilers proved unsuccessful in overcoming the troubles mentioned above.

Equipment was installed for hot lime-soda ash treatment of the water. The essential parts of a mixer for the lime and soda ash are shown in the accompanying diagram. This device permits intimate mixing of the lime solutions and the soda ash solutions before transferring to the treating tank. Best results were obtained by introducing the lime solution first and allowing about 20 minutes of treating action on the hot water in the large tank before introducing the soda ash solution. A diagram of the essential points of a welded pipe heater for the treating tank are also shown in another illustration. The square shape of this heater results in good heating and circulation. With it set approximately 18 in. above the tank floor, there is ample room for the sludge to accumulate without hindering the treating operations and without requiring frequent cleaning out. Excessive vibration is eliminated by the 2-in. pipe bracing welded to the sides of the tank.

The lime-soda treatment of this water gave very satisfactory results. The analysis of the lime-soda treated water shows that its total hardness was satisfactory, and that it had a smaller amount of total dissolved solids than the zeolite-softened water. Best of all the alkalinity in terms of calcium carbonate had been reduced from 12.0 to only 4.0 grains per U.S. gal., and there was only a trace of calcium precipitate reported as suspended matter. The finely divided iron suspended matter and the dissolved gases had been completely removed. Furthermore the alkalinity and the sulphate ratio in the treated water are more definitely controlled so that the possibility for caustic embrittlement in the boilers is reduced to a minimum.

A comparison of the treating costs for the two methods is given in Table II, and shows the lime-soda process is the cheaper method for treating this water. Typical results for one month's operation of each method shows that the lime-soda had a greater capacity, used only one-ninth as much "washing" water, and had a cost per barrel of water treated 38 per cent less. Since the firemen did the treating, labor costs except for cleaning tanks were the same.



Automatic electric motor-driven deep well turbine installation

There was no charge for heating because exhaust steam from the plant was used.

The rotary drilling contractors in this field have found it absolutely necessary to treat all water for use in their boilers. The lime-soda process is used.

Other Uses for Treated Water Around Gasoline Plants

Besides the necessity for treated water in the boilers, experience has proven it to be economical and really a necessity to use treated water in a closed system for the cooling water used in stationary engines and compressors. Strong prevailing winds in this area carry a great deal of dust and sand and with the large windage losses of the water going through the cooling towers the hardness of this water is much larger than that for the well water. Elimination of the scale deposited in the water-jackets of the cylinders has eliminated some of the serious troubles in engine operation in these plants and has made very substantial savings in operation and repair costs.

Likewise, experience has proven the value of using treated water for tubular coolers and reflux condensers. The efficiency of these units is maintained for longer periods of time and much of the work in drilling the scale out of the tubes is eliminated. Worthwhile savings are obtained, particularly in the summer time, when it is necessary to have the cooling equipment as efficient as possible.

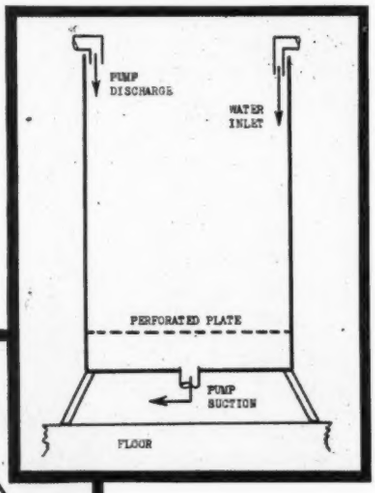
Although it has never been done in this field, it appears that treated water would be very advantageous in increasing the cooling efficiency of the pipe coils in the cooling towers, particularly in the summer time, when the temperature of the cooling water is so high. Thick deposits of scale accumulate rapidly from this naturally very hard water and lower very greatly the cooling efficiency of the coils. Even though the coil suface is greatly increased to get the desired cooling, still the increased investment, the cleaning costs and the decreased production during the warm weather would more than offset the cost of using treated water for at least part of the year. If treated water were used all the time, then it would be possible to use less cooling water to obtain the same degree of cooling and to use a smaller cooling tower to cool the water for this work. The investment would be smaller and windage losses and cleaning costs would be less. Hence, in a carefully-designed installation, it would appear that the treated water would save more than enough to justify the treating expense.

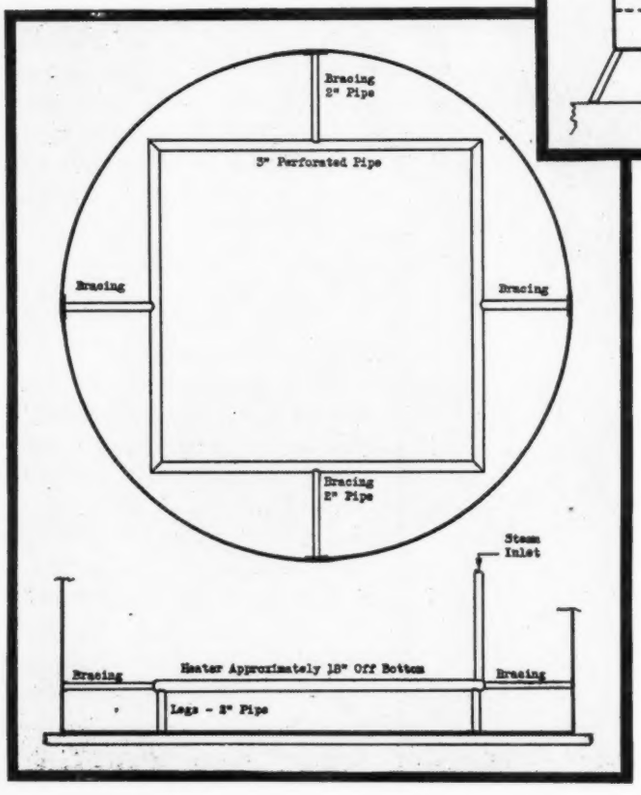
TABLE II

Comparison of Treating Costs for North Side Water

	Zeolite	Lime-Soda
Typical Results for One Month:		
Water treated daily	341 bbl.	710 bbl.
Total water treated	10,583 bbl.	22,000 bbl.
Total water treated for backwashing	2,638 bbl.	.....
Total water used for washing tanks	.....	600 bbl.
Percent water used for washing	24.9	2.7
Cost of water used for washing	$13.20	$ 3.60
Cost of chemicals used	$61.60	$93.70
Total cost of chemicals & wash water	$74.80	$97.30
Cost per bbl. water treated	$ 0.0071	$ 0.0044

NOTE: Labor costs except for cleaning tanks same because firemen do treating. No charge for heating water because exhaust steam used.





Above: Diagram of barrel-size lime-soda ash mixer

Left: Diagram of welded pipe heater for lime-soda ash water softener

In these times possible economies, however small, should not be overlooked. The obtaining of a supply of suitable water is a problem that presents itself in many fields and in many gasoline plants. Not infrequently the use of untreated water becomes such a prolific source of trouble and expense and becomes so great a burden that the treatment of the water becomes imperative. If the problem of water supply is properly attacked at the outset and careful estimates made of probable future water requirements, and a complete water supply and water treating plant installed adequate to supply these needs, it will usually be found that a lot of needless expense and trouble will be avoided later. A thorough investigation of local sources of water supply and the character of the water available will usually repay for the trouble and expense in making such an investigation.

The writer appreciates very much the many courtesies extended to him and the many helpful suggestions made by L. A. Boyd and J. S. Hilligoss of the Signal Oil and Gas Company's plant in the Big Lake field.

Economy in Gasoline Plant Operation

By F. R. STALEY

THE very low market prices for natural gasoline have made it exceedingly difficult to operate gasoline plants profitably, consequently many have been shut down. Production of naturals in the United States continues to decline, the daily average for the first two months of this year being only 92,000 bbl. against 108,000 bbl. for the corresponding period of last year. East Texas and Oklahoma show gains this year, while all the other fields are producing less than formerly. More plants are now being constructed in East Texas.

In order to prevent financial losses all plants have had to make drastic reductions in operating expenses. Efficient plants and intelligent operating personnel are necessary for economical operation. Many companies have reduced costs and eliminated waste by installing modern equipment, the present low prices of which present excellent investment opportunities. Due to scientific research the technical progress of the industry has been remarkable. Equipment has been developed to a high degree of efficiency and flexibility to meet special operating conditions. Improvements in design, materials of construction, and methods of fabrication have reduced investment and maintenance costs. Great progress has been made in the development of automatic control devices, which are absolutely essential for modern plant operation.

Strict Attention to Operating Details and Use of Modern Methods Effect Economies

Various means for effecting economies in gasoline plant operation were discussed by plant operating men at a recent meeting in Breckenridge, Texas. There are many details connected with gasoline plant operation close attention to which will aid in reducing operating costs.

Gas Measurements

In the past gas measurement was concerned chiefly with obtaining the highest degree of accuracy, but today it is necessary to obtain not only accurate readings, but also to obtain them at the very lowest cost. Measurement costs of the Lone Star Gas Company are about 30 per cent of all the gathering costs and less than five per cent of the total operating costs.

The use of 7-day clocks reduces chart-changing expense as well as the time in the office. Although certain wells with erratic flows present difficult problems, none was found where 7-day charts could not be used satisfactorily and with as great a degree of accuracy as that obtained with daily charts. The co-operation of the producer is necessary for good results, but this is now much easier to obtain than it was during more prosperous times. Standardization of charts contributes to both economy and accuracy, since it simplifies chart changing and also handling in the office. An integrator, which has a capacity of 300 charts per day, greatly reduces the cost of figuring charts.

Measurement of residue gas has perplexing problems; quantities are generally estimated, and the estimates checked every month or two. Orifice meters are most satisfactory for checking residue gas measurements; a meter of this type is set to check estimates on residue gas periodically.

As a result of the research work conducted in co-operation with the Bureau of Standards it is now possible to obtain accurate and dependable gas measurements economically. Accurate orifice coefficients have been calculated and checked, and standards for orifice meter settings have been developed. Pulsating flow is about the only source of difficulty remaining unsolved.

Piston Ring Performance

Factors affecting piston ring performance should not be overlooked. The manner in which a ring is installed is important, for an excellent ring improperly fitted will give poor results in service. First of all, the grooves should be inspected to make sure they are straight and free from burs that might cause the ring to bind. The depth of the groove should be measured to insure sufficient clearance so that the ring will not be required to carry the weight of the rod and piston. Side clearance in the groove is important, and should be varied according to the position of the ring on the piston and the service performed, as a ring that is too tight will stick and its effectiveness in sealing fails. A ring fitting too loosely in its groove is noisy and will flare the ring groove and cause inefficient sealing. It is as important for the ring to fit the groove as it is for the face of the ring to fit the cylinder wall.

The gap or clearance between the ends of the ring must be adjusted to the operating conditions, so that the ends will come together when the machine reaches its normal operating temperature. Leakage at this point lowers efficiency, and the gas passing through the orifice at the ends of the ring sets up a cutting action that causes scoring of the cylinder walls. After the rings are properly installed the machine should be operated at reduced load until they are seated to the cylinder walls, during which time the quantity of lubricating oil should be increased to prevent overheating and to wash out any abrasives released by the new rings.

Deposits in the water jackets prevent the transfer of heat from the cylinder walls, hence the importance of the quantity and the quality of the cooling water used. Timing is an important factor affecting power cylinder rings. Late ignition causes overheating of the cylinder and piston. Improper fuel mixture causes overheating and destroys lubrication.

The selection of the proper ring for the job is of major importance, since there are numerous kinds on the market. An accurate record of ring renewals will serve as an invaluable guide in the selection of rings. The condition of the cylinder at the time of renewal should be recorded. A ring that gives excellent service in a new or rebored cylinder may be unsuited for a tapered cylinder. In the latter a softer grade of iron should be used and the ring given more tension. The purpose is to secure a quick-seating ring that will be quickly adjusted to the imperfect condition of the cylinder. A more flexible job can be obtained by installing two narrow rings in a groove instead of a single wide one. If these rings are properly spaced the gap at the ends will be more effectively sealed. This procedure can be used in salvaging old pistons

when the ring grooves have become tapered and the installation of a wider ring is not desirable.

Lubrication

The proper lubrication of compressors, motors, and other types of machinery used in gasoline plants is one of the most important factors in their economical operation. Large sums have been spent by oil refiners in the development of lubricants for all types of modern machinery, and lubricating instructions are furnished with every machine. Every operating man should understand the basic principles of lubrication and be familiar with the general properties of lubricating oils and greases. It is important to use the correct quantity of the proper lubricant on a machine, for excess lubrication, as well as the lack of it, is harmful, besides being wasteful.

In discussing the life of motors and their lubrication, J. I. Clower[1] points out the following factors: Operating temperature, size of motor, speed, and method of lubrication. The viscosity of an oil varies with temperature, and it should have the proper viscosity at the operating temperature. Oil used in motor circulating systems should be highly refined, well filtered, and chemically and physically stable. Oil of the correct body and film strength must be employed suitable for the size and speed of the motor.

Over-lubrication of motors draws dust, causing sparking, and impairs ventilation, causing excessive heating.

Special lubricating oils have been developed for high-pressure cylinders handling condensable vapors, which form liquids that wash away oil films from the cylinder walls. Some operators have overcome this trouble by blending ten per cent of castor bean oil in the proper mineral oil.

Petroleum, which is a hydrocarbon substance extracted from lubricating oils in order to lower their pour tests, has been found to be an excellent coating to put over iron or steel surfaces to prevent rust. It is stable under atmospheric conditions.

M. O. Marsh[1] has listed some uses of small transformers that might prove advantageous in the natural gasoline plant. The hazard of portable lamps can be eliminated by using a 32-volt circuit instead of 110 volts. Electric welded or brazed wire joints are superior and resist heat better than soldered joints. Lead burning can be done electrically. Cooling coils can be defrosted rapidly, and frozen water lines thawed conveniently with low-voltage current.

Many operating companies have found it economical to install dust-removing equipment on gas inlet lines to eliminate deposits in the absorption towers, thus making their operation smoother.

Painting, appearance, and good illumination are important factors in economical plant operation. Safety, morale, and personal efficiency are promoted as a result.

Control Instruments

On account of existing proration methods many plants are operated under fluctuating loads. Automatic control of continuous operations regardless of load changes has been accomplished by the development of new temperature and pressure regulators. The straight-line precision control of a stabilizer operating under variable loads is shown by the chart (see illustration). The check marks show the time when the load was changed.

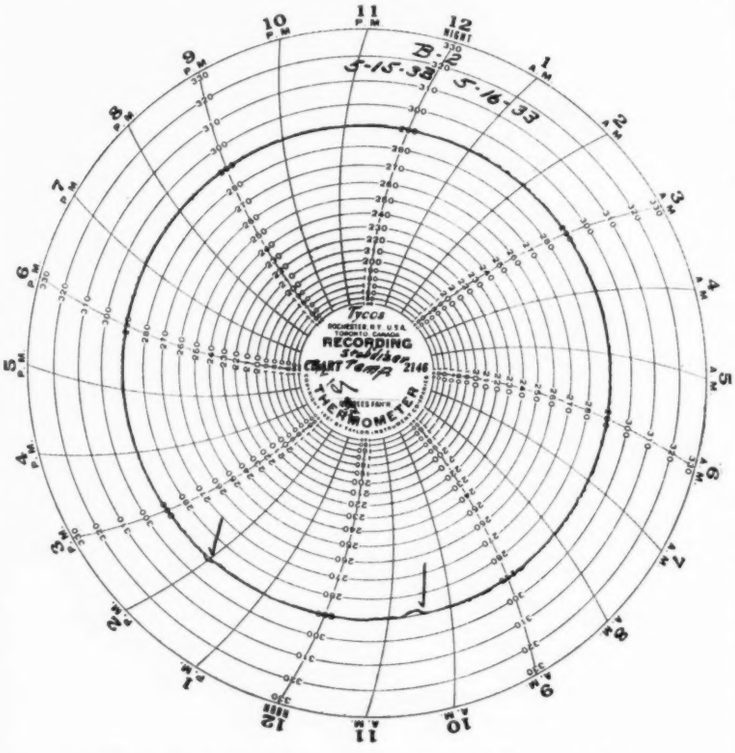


Chart showing precision control of a stabilizer operating under variable load

The operation of the control is such that the valve is permitted to assume any position of opening necessary to satisfy load conditions while maintaining control of the original setting point. In operation (see sketch) the actuating bellows receives air pressure changes from the regulator, due to pen arm movement, and places the baffle in position with respect to the nozzle. Clearance between the baffle and the nozzle determines the position of the relay air valve, and the air pressure is admitted to the valve diaphragm. Increased pressure drives the valve stem downward and the push rod upward. The push rod is attached at the lower end to a pivoted lever in contact with the valve stem just above the stuffing box, at the upper end to the nozzle box. Responsive movement of the valve stem is exactly proportional to the baffle movement since it must continue until baffle nozzle clearance is correct.

The cycle just described is the initial one, the valve response and the magnitude is always proportional to the deviation of the pen arm from the control setting. By the time the process has begun to absorb the initial valve movement a second response is started. This action is independent of the pen arm position and is associated with a damping device and the pivoted levers connected to the baffle. This secondary response determines the final position of the valve and does so with micrometer effectiveness. The damping device is adjustable to match the approximate time lag of the process, by which is meant the delay between change in input of controlled medium and response of the regulator.

By taking advantage of modern, up-to-date equipment and paying strict attention to operating details in the plant substantial economies can be made. Those in charge of gasoline plant operation cannot afford to overlook any possible aids toward a reduction in operating costs. Only by being constantly alert to the trend of progress can an adequate efficiency be maintained that will enable operators to run their plants on a profitable basis.

[1]Maintenance Engineering, February, 1933.

Open Side Pipe Vise

THE TOLEDO PIPE THREADING MACHINE CO., Toledo, Ohio, has announced a new line of open side pipe vises. These are made in three sizes, No. 00, capacity ⅛-in. to 1½-in. pipe inclusive; the No. 0, capacity ⅛-in. to 2½-in. pipe inclusive; and the No. 3, capacity ⅛-in. to 4½-in. pipe inclusive.

As shown in the illustration they have a very heavy frame and long full overlapping vise jaws. The jaws are made from tool steel, properly hardened, and when they become dull may be easily replaced. The handles are all over-sized and extra long, thus permitting easy setting of the jaws and giving an extremely great leverage.

The manufacturer recommends these vises as being excellent for fitting make-up work, as the jaw construction permits working close to the face of the vise, and will hold copper as well as iron or steel pipe.

Each vise is thoroughly greased and packed in a separate carton to insure reaching the customer in first class condition. The manufacturer will be glad to quote net prices to any one interested.

Enclosed Air Circuit Breakers

GENERAL ELECTRIC COMPANY, Schenectady, New York, has announced a new line of manually and electrically-operated, trip-free, multipole air circuit breakers for the control and protection of circuits. These breakers, designated as Type AB-2, are obtainable in metal-enclosed construction, with or without pull box; metal-enclosed with pull box and disconnecting devices to permit inspection of the breaker while it is disconnected from the source; or mounted in dead-front and metal-enclosed switchboards which are shipped assembled from the factory.

Ratings of this new apparatus range from 15 to 400 amperes, 250 volts d.c. and 600 volts a.c. This type of breaker has high interrupting capacity, since, when the breaker opens, the circuit is transferred from main contacts to intermediate contacts and then to arcing horns by the rapid action of a magnetic blowout.

Trench Guards

THE CLEVELAND TRENCHER COMPANY, manufacturer of wheel and ladder type trenchers, the combination tamper-backfiller and Penote manhole forms, has announced a new product —Cleveland Trench Guards.

These patented, interconnected metal trench and excavation guards have many interesting practical features that make them most efficient.

The illustration above shows the design and construction of these new guards and demonstrates how practically a series of them will enable the user quickly to construct a complete, unbroken fence entirely around any shape of excavation or alongside any trench. The fact that the "Guard Rail Holder" swivels in any direction, assuring equal efficiency no matter at what angle the rails are set, makes it novel and unique. The flexibility thus obtained increases very materially their usability.

A feature of the Cleveland Trench Guards is that they are interconnected. This connecting of the rail cuts in half the number of supports required on any job and sets the alternate rails at different heights.

Another feature that is exclusive to Cleveland Trench Guards and increases their value, because of the added safety, is the combination lantern and flag support, which places either well above the guard rail, and in full view from every direction. Flag or lantern is secured in position by the insertion of pin or nail, thus minimizing considerably the chance of loss or theft of the flags and lanterns.

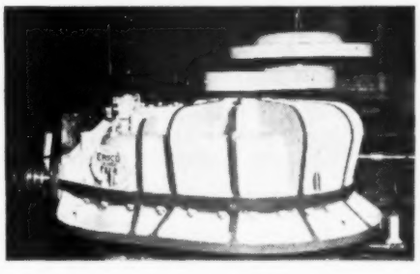
These new trench guards, strong and durable, made of rust-proofed malleable iron, will deliver long service and assure economy because of the elimination of the breakage and replacement constantly necessary with the old type wooden horse.

The galvanized pipe legs and lantern-flag supports are threaded for ease in setting up and dismantling and the entire guard can be conveniently packed in small space for transportation.

Emsco-Falk Geared Power

THE EMSCO-FALK 160 M.G.P. geared power has recently been placed on the market by the Continental Supply Company, St. Louis, Missouri.

The construction of this geared power includes a well reinforced housing; powerful, efficient, oversized gears and bearings; automatic lubrication;



careful proportioning of parts, and rigid anchorage to the foundation.

The housing, made of grey iron, has a very heavy metal section and unusu-

ally heavy ribs, in both the upper and lower halves. Even the "oil pan" is ribbed so as to anchor it more rigidly to the foundation.

The power is equipped with a single crank having a stroke of 36 in., and a crank disc with connections for 20 wells. The overall ratio is 32 to 1, which works out effectively with gas or oil engine or electric motor drive through V-belts.

The gears are silent and efficient throughout, according to the distributors. The first reduction is spiral bevel, giving the required right angle turn. The second reduction is single helical, reducing the required speed with the same degree of silence and smooth performance. The pinions and gears in both reductions are made of the best alloys obtainable, each suitable for its own specific purpose; each heat treated and hardened and cut with accuracy in tooth spacing and tooth form.

The high speed pinion is supported by a Norma Hoffman precision type straight roller bearing for radial load at the inner end, and by a double Timken unit type non-adjustable bearing at the outer end to carry the thrust load. The low speed pinion shaft is supported in the same manner. The crankshaft is supported at the lower end by a Norma Hoffman floating type roller bearing to carry the radial load, and the upper end by an exceptionally heavy double Timken unit type non-adjustable fixed bearing to carry both the thrust load of the gear and heavy radial loads of both gear and overhung crank.

The lubrication of the unit is said to be complete, thorough and automatic. Seventy gallons of oil are stored in the bottom of the case. A positive self-priming reversing helical gear oil pump with by-pass valve is mounted on the cover and is driven through a set of speed increasing gears from the intermediate shaft. This provides a sufficient volume of lubricating oil when the wells are pumped at a speed of only 6 s.p.m., yet producing no excessive pressure should the wells be pumped at 30 strokes per minute.

Link-Belt Flexible Coupling

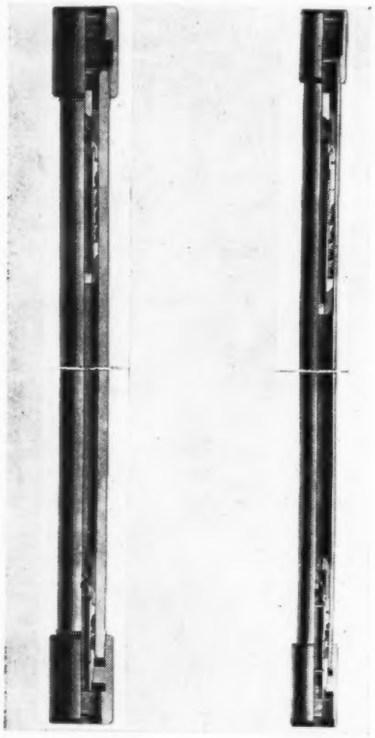
Link-Belt Company, Indianapolis, Ind., announces the development of a new flexible coupling in which the company's recently-announced "RC" silverlink roller chain will be used.

The new coupling, known as the Link-Belt "RC" flexible coupling, consists simply of two cut-tooth sprocket wheels (or coupling halves) and a piece of roller chain to connect them, all working surfaces being machined to close tolerances. A pin-and-cotter link makes it easy to couple or remove the chain when desired.

Where the operating conditions suggest the advisability of protection from dust, dirt or other adverse conditions, the coupling can be enclosed in either a stationary or revolving automatically-lubricating oil-retaining casing.

Oil Well A.P.I. Working Barrels

The Oil Well Supply Company, Dallas, Tex., has announced an improved line of precision-made A.P.I. working barrels. These are made in two



types—nickel-alloy cast iron and cold-drawn steel. The nickel-alloy cast iron barrels are furnished with either regular or reinforced ends, the latter being of larger outside diameter than the center section and recommended for severe service, especially where pumping depths exceed 4000 feet.

The improved A.P.I. nickel-alloy cast iron working barrel is cast in one solid piece and annealed to render it more resistant to strains and to prevent warping. The solid casting is bored on a special machine which maintains a straight bore from end to end. The bore is reamed and finally ground and honed on a specially constructed machine that gives it a true and mirror-like gun-barrel finish.

The impoved Oil Well A.P.I. cold-drawn steel working barrels are made of special cold-drawn Shelby tubing, insuring straight and uniform bore and maximum wall strength. The bore is given a polished finish by a special process.

The traveling and standing valves for these barrels are of the latest A.P.I. design with special features assuring maximum efficiency and outstanding performance, according to the manufacturer. All cages are machined for close clearance and short lift, increasing efficiency and life of the valve parts. The top of each guide is square so that either a ball or drop may be used in the same cage.

Valves are equipped with either the new standardized high-grade Oilwell A.P.I. balls and seats or the new Oilwell Type C drops and seats.

Bulletin No. 109 describing the design and construction of the improved Oilwell A.P.I. working barrels has been prepared by the Oil Well Supply Company and will be forwarded on request.

"Cured-In" Tire Tube Valve

A "Cured-In" valve in which the valve base is vulcanized to the valve pad, which in turn is vulcanized to the tube, making the valve pad and tube an integral unit so that leaks at this point are practically eliminated, is announced by The Goodrich Rubber Company, Akron, Ohio.

Before its adoption, the new valve principle was thoroughly tested on buses where frequent brake application develops high temperatures. These tests and actual field research have proved that the valve, with this new construction, is no longer a source of slow air leaks at the valve base.

The tire industry has constantly been faced with the problem of building a heavy-duty tire that would resist abuses of overload, quick starting and stopping, and extreme heat developed by high speeds. In many cases the trouble usually attributed to heat in the tire actually developed from the loss of air at the valve base.

The new "Cured-In" valve construction has been used on the popular sizes for high speed, long distance truck operations where extreme heat conditions are encountered. It will be extended to the entire line of Goodrich Heavy Duty tubes in all sizes used in truck and bus service.

Solving Well Pumping Equipment Problems

ARTICLE III

By HYMAN LEEDEN

Engineer-in-Charge, Western Division, The Falk Corporation, Milwaukee, Wis.

The Transmission

SINCE the operating speed of the pumps must range from 1 to 30 s.p.m., and the best operating range of internal combustion engines lies between 200 and 1200 r.p.m., and of electric motors between 600 and 1800 r.p.m., it becomes necessary to introduce some sort of transmission between the prime mover and the pump—a transmission that will reduce the necessarily high prime mover speed to the desirable low pump speed. This transmission must not only change the speed, but it must transmit it smoothly, and must deliver it without superimposing upon either prime mover or pump any internally-generated shocks or jerks.

The pump itself, due to its reciprocatory motion, is bound to have fluctuating load requirements. At the beginning of the cycle a large amount of power is required to accelerate the rods and oil. Toward the end of the cycle the acceleration has all taken place and little power is required. Numerous indicator cards show that the power demand has an exceedingly wide range between minimum and maximum during the pumping cycle.

As efficient operation cannot be expected from either an electric motor or an internal combustion engine under such fluctuating demands, it becomes desirable to introduce between the prime mover and the pump some energy-absorbing system, either a stabilizer, a flywheel or gyroscope that will take up the power from the engine or motor at the instant that it is generated, absorb it, and store it up so as to redeliver it to the pump at the instant that it is required.

This stabilizing element usually takes the form of a counterbalance, mounted on the beam, pitman, or crank. When no counterbalance is used, the load to be lifted on the upstroke is equal to the weight of the rods plus the weight of the oil. On the downstroke the load becomes negative and tends to run away from the prime mover. The motor or engine must, therefore, labor heavily on the upstroke and either idle or act as a generator on the downstroke. It must have sufficient capacity to lift both the weight of the rods and the weight of the oil, and to accelerate them from a zero velocity at one part of the stroke to the maximum encountered at another part of the stroke. It will, therefore, run at less than full load for most of the upstroke, and at negative load for the downstroke, both conditions making for extreme inefficiency. Under such conditions the reversal of stress occurs twice during each pumping cycle, sufficient to destroy sucker rods, shafts and other elements. Counterbalancing is an effort toward reducing some of these undesirable conditions by equalizing the load between the upstroke and the downstroke. The counterbalance is usually made equal in weight to the rods plus one-half the weight of the oil. This is only an approximate method. A better method that has recently found favor involves the use of the dynamometer. An indicator card is taken, and the weight selected, such that the area of the card above the weight is equal to the area of the card below the weight.

By correctly counterbalancing, desirable economies in pumping costs have been effected. Sucker rods break less frequently, and other equipment gives less trouble. Although a counterbalance will divide the load approximately between the upstroke and the downstroke, there still remain fluctuating load requirements caused by accelerating from zero to maximum velocity in each half stroke that cannot be taken care of by counterbalancing; however, they can be taken care of by a flywheel.

What a counterbalance is to the pumping cycle as a whole, a flywheel is to the individual stroke. Counterbalancing divides the load between the upstroke and the downstroke; a flywheel divides the load between different points on each stroke. During the periods on each stroke when the power demands are light, the prime mover stores energy in the flywheel, and when the power requirements are heavy, the flywheel returns some of the energy that has been stored in it, keeping the load on the engine or motor smooth and uniform.

An internal combustion engine already has a flywheel incorporated with its crankshaft, but as this flywheel is intended only to make its power output approach the smoothness of an electric motor, an additional flywheel is required between the engine and the pump.

Since the effectiveness of the flywheel varies as the square of its speed, it is sometimes advisable to increase the speed of the high-speed shaft of the gear unit on which the flywheel

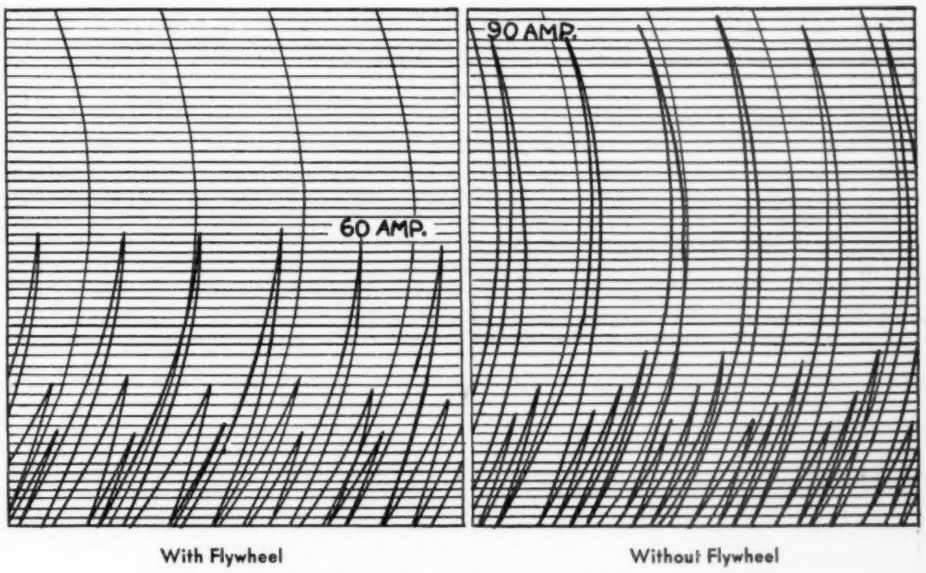


Figure 1—Effect of Flywheel on Current Consumption

JONES
SUCKER RODS
« PULL RODS »
POLISHED RODS

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Rods to Meet All Conditions

Jones' Developments
Are Usually Followed

THE S. M. JONES CO.
TOLEDO, OHIO
19 Rector Street, New York City
McBirney Building, Tulsa, Oklahoma

TABLE 24

Speed Changes During Pumping Cycle

Well	Speed Change	Percent Change	Av. HP.
W. O. ALLEN No. 2	795–895–845–900	12.5–6–6–13	
	815–900–850–900	10 –6–6 10	
	805 880–840–910	9 –5 8–13	22
J. J. DAVIS No. 3	832–891–862–891	7 –3–3– 7	
	845–880–862–900	4 –2–4– 6	
	843–901–857–878	7 –5–3– 5	19

is mounted above that of the engine speed. For example, a 200-r.p.m. gas engine under normal conditions is connected to the crankshaft, operating at 20 r.p.m. by means of a single belt from the engine pulley to the crankshaft pulley. If, however, it is desired to get the full benefit of the flywheel, the 200-r.p.m. engine can be connected to a gear unit at 600 r.p.m. with a suitable flywheel mounted on the high-speed shaft. The gear unit should have a reduction ratio of about 30 to 1, reducing the speed to the 20 s.p.m. desired.

The inertia effect of a flywheel, which permits the storing and the restoration of power, is given in terms of WR^2 where W is the weight of the flywheel in pounds and R is the radius of gyration in inches. If the flywheel is a solid disk, the radius of gyration is 0.7 times the outside diameter divided by 2, or $R = 0.707D/2$. For a flywheel consisting of rim and arms, or rim and disk, the ratio of the rim weight to the arm or disk weight is so high that the radius of gyration of the flywheel as a whole is taken as the radius of gyration of the rim itself. The radius of gyration of the rim is figured by the formula $R = \sqrt{D^2 + d^2}$ where D is the outside diameter and d is the inside diameter of the rim. The energy E in horsepower-seconds, stored in the flywheel at any r.p.m. N, is $E = WR^2N^2/465{,}000{,}000$. The energy delivered to the pump will depend on the change in speed of the pump. Shutts & Thomas ("Efficient Operation of Pumping Rigs," A.P.I. June, 1930) show changes in motor r.p.m. due to changes in pump speed as in Table 24. These changes take place in about one-quarter of a stroke, so that when pumping at 15 r.p.m., the change in speed takes place in one second, and the flywheel must do its work during that period.

The effect of the flywheel can be more readily seen by taking a specific instance. A gear unit is available having a flywheel with 93 hp.-sec. capacity at 1000 r.p.m. to get the desired pumping speed, a ratio of 43.5 could be used, giving 870 r.p.m. of the flywheel and therefore using a one to one V-belt connection to the motor. The capacity of the flywheel at this speed is $(870/1000)^2 \times 93 = 70.5$ hp.-sec. We then get the conditions in Table 25.

The flywheel would probably not permit speed fluctuations as low as the 13 per cent shown by Shutts & Thomas. It would keep the speed steady so that the speed fluctuations would be somewhere between three and five per cent. Under these conditions the flywheel helps the motor by 19 to 31 per cent. Or, to put it in other words, to carry the load over the peaks, the motor must do 20 to 30 per cent more work without a flywheel than with a flywheel.

Fig. 1 is a reproduction of an Esterline chart showing the fluctuations of load within a motor while pumping a well in the Mid-Continent field. This fluctuation of load may be taken as being the fluctuation of power requirement by the pump itself. The curves at the right were obtained when no flywheel was used; the peaks encountered were such that the average load during each pumping cycle was about 25 horsepower. The curves at the left show the fluctuation of load on the same well after a comparatively small flywheel was added. The peaks were such that the average load was reduced to 20 hp.; at the same time the temperature of the motor dropped 36 deg. fahrenheit.

The interposition of the flywheel between the motor or engine and the pump is important, as it results in smoother action and reduced power and maintenance costs.

Both belts and chains in their single reduction form, are automatically eliminated when the speed of the prime mover is increased materially above 200 r.p.m. and the speed of the pump is decreased materially below 20 s.p.m. It then becomes necessary to introduce a second reduction to accomplish the desired speed change.

If the motor is stepped up in speed to 600 r.p.m., and the pump down to 15 s.p.m., a total reduction ratio of 40 to 1 is necessary. To meet the new requirements, equipment manufacturers developed a double reduction chain-driven or combination chain-and-belt-driven rig front. In the chain-driven rig front, the motor connects through high-speed chain to the countershaft, and then through low-speed chain to the standard rig front. In the combination drive, the gas engine connects by belt to a reverse clutch or countershaft and then by standard chain, or perhaps by belt, to the standard rig front.

The herringbone gear, which is the equivalent of two helical gears with the helices opposed, automatically neutralizes end thrust and makes it possible to mount the gears on radial bearings of suitable roller or sleeve type. It is smooth and efficient in operation, and if built of the proper dimensions and materials, will give long, uninterrupted service.

Earlier forms of herringbone gears were built with a ratio of 40 to 1, with 45 to 1 or 50 to 1 as an outside limit. The introduction of the V-belt made it possible to use a single reduction herringbone gear unit having a total ratio of about 10 to 1, connected to the motor by a V-belt having a total ratio of from 3 to 1 to 4 to 1.

Since the V-belt can be used satisfactorily up to ratios of 6 or even 7 to 1, the 600-r.p.m. motor was soon replaced by the 900-r.p.m. "Y" motor. This meant the use of a 6-to-1 V-belt for 15 s.p.m., or a 3-to-1 V-belt ratio for 30 s.p.m. This type of transmission was found to be so satisfactory, both in life and efficiency, that it has since become almost a standard in the industry in those cases where geared transmissions are used. The gear gives the smooth and positive transmission that is desired, the V-belt gives flexibility, and the overhung mounting of the V-belt pulleys makes it possible to change speeds readily, by a simple change in one V-belt pulley.

However, engineers in studying the problem of greater efficiency and economy in the operating of pumping wells, found it advisable to go to still lower pumping speeds than 15 s.p.m. and to still higher motor speeds than 900 r.p.m. This additional requirement has been met by a triple reduction unit, consisting of a double reduction herringbone gear unit, connected to a motor or engine by a suitable V-belt drive. In the double reduction gear unit ratios ranging from 11 to 1 up to 70 to 1 are possible. V-belt ratios may range from 1 to 1 up to 7 to 1. This gives a total ratio of from 11 to 1 up to 490 to 1, making the unit most flexible.

The triple reduction unit, when used with the 600-r.p.m. motor, allowed of slightly over 1 s.p.m., and when used with a 1800-r.p.m. motor, pumping speeds slightly greater than 3 s.p.m. can be obtained without difficulty. Where higher

TABLE 25

Flywheel Effect Due to Speed Change in Pumping Cycle

	Standard Speed	1% Change	2% Change	3% Change	4% Change	5% Change	10% Change	
Speed	870	862	854	845	836	827	784	R.p.m.
Energy Stored	70.5	69.1	67.9	66.3	65.0	63.6	57.2	Hp.-sec.
Energy Given Up	0	1.4	2.6	4.2	5.5	6.9	13.3	Hp.-sec.
Percent of 22 hp.		6.4	12	19	25	31	60	

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TABLE 26
Variation of Efficiency With Type of Transmission

Type of Transmission	Variation of Efficiency
Belt	35%
Worm Gear	40%
Chain	50%
Spur Gear	60%
Herringbone Gear	75%

speeds are required, a ratio of 58.2 to 1 in the gear unit and 1 to 1 in the V-belt drive will give pumping speeds greater than 30 s.p.m. when connected to an 1800-r.p.m. motor. When connected to a gas engine, a ratio of 29 to 1 for self-servicing wells, and 58 to 2 for only pumping wells is usually used, and an effort is made to step up the speed from the engine to the gear unit, so that better flywheel action can be obtained. A study of the speed range that will be desired on the well during its operating life, determines the choice of ratio in the gear unit with a given prime-mover speed.

For example, in East Texas, where production is assumed as limited to a fluid volume of about 70 bbl. per day, six s.p.m. is found the most desirable setting. A 1200-r.p.m. motor, connected by 7 to 1 V-belt ratio to a 29 to 1 gear unit produces a pumping speed of about six s.p.m. at around 44-in. or 54-in. stroke. By changing the V-belt ratio from the 7 to 1 now used to 11½ to 1, which is easily possible, the pumping speed can be stepped up to as high as 30 s.p.m., and production increased to more than 1000 bbl. per day. The same gear unit can be connected to a 150-400-r.p.m. gas engine and a suitable V-belt, and will give the same pumping speeds and production.

Choice of transmission, like choice of pump or motor, can have a serious effect on the monthly power costs. Various investigators have given reports of tests on overall efficiencies from wires to polish rod, for different types of transmissions. These tests have not been altogether consistent due to different conditions and operators, but they do show a trend that is substantially correct.

Assuming that the pump will be operated at the most favorable conditions of 44-in. stroke, 5.7 s.p.m., the efficiencies may be set as in Table 26.

Assuming a pump requirement of 5.18 hp. the required motor horsepower and power bill (based on an average cost of 1c per kw-hr., including demand and power factor charges) are shown in Table 27. Although the figures in Table 27 are comparative and open to criticism, they demonstrate that pumping costs are materially affected by the type of transmission used.

It has previously been shown that the ratio between operating a pump or motor at its best and worst is also over 2 to 1. The total ratio of operating each element at its best or at its worst may easily rise to 8 to 1 or even 10 to 1. The savings made possible by operating under the best conditions will go a long way toward paying for modern pumping equipment.

The modern oil field transmission for pumping purposes should, therefore, have the following characteristics:

1. It should be the most efficient possible in operation.
2. It should incorporate a flywheel that absorbs the shocks

TABLE 27
Variation of Pumping Costs With Type of Transmission

Type of Transmission	Hp. to Polish Rod	Hp. Input to Motor	Cost Per Month	Cost Per Bbl.
Belt (Double)	5.18	14.80	$79.60	3.80c
Worm Gear (Single)	5.18	12.95	69.70	3.32
Chain (Triple)	5.18	10.35	55.60	2.64
Spur Gear (Double)	5.18	8.65	46.50	2.25
Herringbone Gear & V-belt	5.18	6.92	37.20	1.74

coming in both directions, from engine and pump.

3. It should make possible the efficient operation of the pump by long stroke and slow speed.
4. It should make possible efficient operation of the motor or engine through the best suited speed.
5. It should reduce initial cost of either engine or motor, due to the higher speeds that are possible.
6. It should require a minimum of attention, and be self-lubricating.
7. Its maintenance cost should be a minimum.
8. It should provide for change of speed and stroke as conditions require.

Such transmissions are available in the market today.

Final Plans Being Made for Houston Show

Final plans for the Oil Equipment and Engineering Exposition, which will be held at the Convention Hall, Houston, Texas, from May 22 to 28, inclusive, are rapidly nearing completion. Work on the installation of some of the heavier equipment is practically completed, while many of the companies showing specialties have already started to fix up their booths.

Equipment including all types of specialties as well as the more or less standard tools and machinery will be presented by manufacturers from many parts of the United States. Every branch of the industry will be covered with equipment for use in production, drilling, refining, natural gasoline manufacturing, pipe lines and marketing operations. Drilling equipment will include complete rigs and other surface tools and equipment, together with bits of all classes, core barrels, tool joints, casing, fishing tools and other equipment used for sub-surface work.

Many interesting displays of production equipment will be seen among which will be complete pumping units with both gas engine and electric motor drives, pumping jacks, well pumps, tubing, rods, tanks, etc.

Equipment for refineries and natural gasoline manufacture will range from small precision instruments up to heavy compressors and cooling towers. Pipe line equipment will consist of pipe cleaning machines, protective coatings, auxiliary equipment, welding machinery and trucks.

American Cable Opens Houston Office

The American Cable Company, manufacturers of Tru-Lay Preformed and "Crescent" Brand wire ropes, has established a district office in Houston, Texas, under the management of C. A. Perryman. This new office is in connection with the company's warehouse in Houston and the large stocks carried of all lengths, sizes, grades and constructions will enable the concern to give excellent service.

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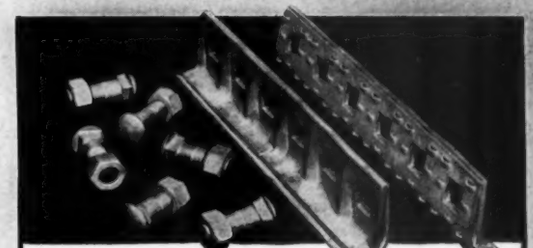

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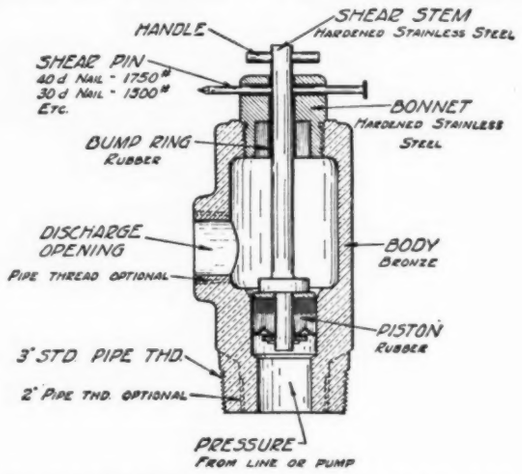

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MANUFACTURERS' LITERATURE

COLOX mud-conditioning material for rotary drilling fluids is described in an interesting bulletin embodying a number of valuable tables and other engineering data and offers other information for reference of drilling contractors. Methods of calculating mud content, determining specific gravity, how to increase the weight of drilling mud by adding clay per cubic foot and per gallon, also the relation between specific gravity, mud weights and pressure head, are presented in mathematical and table form.

A copy of this bulletin may be obtained by writing to the manufacturers of Colox, Geo. S. Mepham & Co., East St. Louis, Ill., or C. K. Williams & Co., of California, Emeryville, California.

KEROTEST CAST STEEL THROTTLE VALVES for the control of drilling engines is the title of a bulletin recently prepared by the Kerotest Manufacturing Company, Pittsburgh, Pennsylvania.

Price New Brewster Company Manager

A. O. Price has been made manager of The Brewster Co., Inc., manufacturers of drilling and producing equipment, Shreveport, La., succeeding H. C. Brewster, whose untimely death occurred two months ago. Mr. Price for the past 12 years had been sales manager of the company and has an exceptionally broad acquaintance throughout the indu try.

Macadam Engineering Company Formed to Serve Industry

J. M. McGregor, formerly of the Byron Jackson Pump Company and more recently handling the Chapman valve account for Taubman Supply Company, and F. G. Adam, formerly chief engineer for the Standard Paving Company, Tulsa, have formed an organization known as the Macadam Engineering Company. They will specialize in engineering, sales and service for oil, water and other industries. The office of the company is at 2119 E. 11th St., Tulsa. The firm will act as sales representative for Coffing Hoist Company, Redwood Manufacturing Company and United Iron Works.

Death of M. F. Brennan

Michael F. Brennan, 39 years old, Mid-Continent district manager for the Bradford Motor Works, died in a Tulsa, Okla., hospital on the morning of April 17, following an illness of three months. The deceased came to Tulsa from Bradford, Pa., 15 years ago to represent the Bradford Motor Works, manufacturers of oil well equipment, and became widely known in the entire Mid-Continent.

His widow and two children survive him. R. J. Brennan, an executive of the Forest Oil Corporation, Bradford, Pa., is a brother; and another brother, H. W. Brennan, also lives in Bradford.

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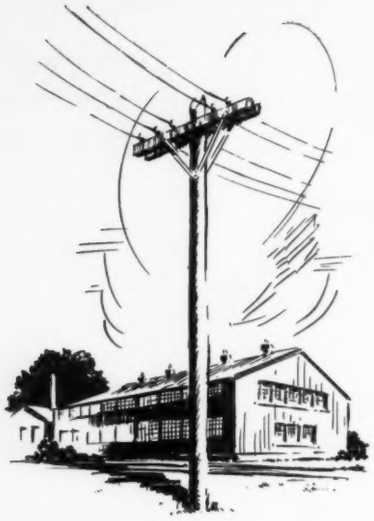


Modern Telephone Part of Efficient P

Urgent Messages Involving Details Now Telephoned

WHILE it is true that every branch of the industry has been retrenching and strengthening its position, the past three years have seen a very definite trend among pipe line companies toward the increased use of the telephone as a means of communication between stations. Of the few recently constructed pipe lines requiring an extensive communication system, the great majority have paralleled their right-of-way with telephone circuits, while others, older lines, have dispensed with their sounders and keys and revamped their lines for telephone work.

As with most industrial adaptations, certain changes were necessitated before the layouts used by commercial service systems could be pressed into the service of the pipe line companies. It is imperative that the system of communication installed result in low operating and maintenance costs. It is equally necessary that the service be as free of interruptions as possible and that the service itself be swift, positive and flexible. The advantage of the telephone lies chiefly in the swift and positive service rendered, particularly where dispatch work, pressure or pumping orders, or lengthy explanations are involved.

Although interruptions in service will probably never be entirely eliminated, the Panhandle Eastern Pipe Line Company, over a two-wire metallic line exceeding 620 miles in length, to which 27 'phones are permanently connected, attained the high efficiency of 97.56 per cent for the year of 1932. This line was completed in the early summer of 1931 and parallels their 24-in. gas transmission line from its gathering systems in the Texas Panhandle and the Hugoton fields, to the Louisburg Compressor Station, three miles from the Missouri state line in eastern Kansas. At this point a two-wire loop was leased that completes the circuit through the Kansas City-Southwestern Bell exchange to the head offices of the company in the Fairfax Building, Kansas City.

O. R. Dunham, present head of the communications department of the company, who had previously had 14 years of varied experience in telephone construction and maintenance, personally superintended the construction of the line. Numerous unforeseen difficulties were encountered and overcome during this work as well as later during initial operation.

The right-of-way obtained for the telephone line paralleled the pipe line right-of-way as nearly as conveniently possible. However, it was for an advantage in future maintenance and trouble shooting as well as economy in construction to follow class "A" or "B" highways wherever possible. Natural obstacles, such as extensive timbered sections, streams, hedged section lines and irregular terrain also played an important part in the choice of the route.

Construction of Line

The Panhandle telephone system begins at Fritch, Tex., in the producing area. Thirty-five poles were used to the mile, and the two wires are held upon the cross-arms by means of standard-type glass insulators, screwed on wooden cross-arm pegs. The insulators differ only in size from those commonly used, being a trifle larger.

As the company wished to eliminate if possible the use of repeating coils, boosters, or other kinds of speech amplifiers and their attendant upkeep, it was decided to string a slightly larger wire than is ordinarily used for similar circuits. Copper wire of No. 8 B.W.G. was chosen as having the necessary strength, and reducing as far as practicable, the resistance to a voice-modulated current. This size wire, 0.165 of an in. in diameter, has a resistance of 4.19 ohms per mile of two-wire line. The resistance per mile (4.19 ohms) fluctuates slightly with temperature changes and increases somewhat with time as corrosion occurs. The accuracy of this figure is important in calculating the location of shorts and grounds.

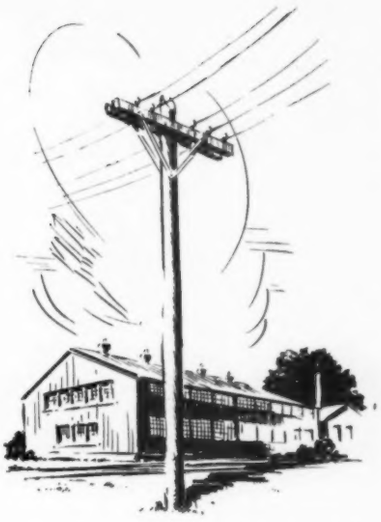
Connections at river crossings and points where the line may be opened are all of the double-barreled sleeve type. The wires from each direction are slipped through opposite segments of the sleeve, then bent back and soldered.

The use of steel-cored wire was avoided as far as possible for although its strength is considerably greater than pure copper, its resistance is excessive. At the Canadian River, near Sanford, Tex., it was necessary to have a single span 3420 ft. long. "H" fixtures were used from which to suspend the wire, and a 19/32-in. strand cable was hung over the river from strain-type insulators. Midway between the "H" fixtures the sag is 259 feet. This same method of river crossing was used wherever necessary and to date has given no trouble.

The transposition of the wires is a problem that is dependent upon various conditions, the most important being

Circuit Essential Pipe Line System

By F. B. TAYLOR, JR., Chief Dispatcher
Panhandle Eastern Pipe Line Company



the proximity of the line to high-voltage alternating carriers. Any alternating current will induce a weak current of similar frequency in a parallel line. Thus the two should be as far apart as possible. However, where this is not practicable, frequent transposition of the two wires of the telephone circuit —that is, reversing their position relative to each other upon the cross-arms—will tend to reduce the strength of the foreign current. This negation is due to the fact that a current induced in one wire will be, after passing through a transposition, counteracted by the newly induced current upon the opposite strand. Natural background noise may be almost entirely eliminated by transposition.

It is interesting to note from the foregoing that every precaution was taken to make the system as low-loss as possible. The present ease with which it carries a speech-modulated current proves the value of the attention to detail.

While it is seldom possible to estimate accurately the total installation cost of a telephone system, as the requirements and variables are unlimited, the 620 miles of line installed in the Panhandle system provides a reliable basis for computation. River crossings, and other natural obstacles included, the cost of a two-wire completed transmission line will approximate $625 per mile. This figure includes right-of-way, transportation of equipment, labor, cost of material and supervision.

Two switchboards are on the line, one at the Liberal, Kan., Compressor Station, and the other at the Louisburg, Kan., Compressor Station, In conjunction with the Louisburg switchboard is a complete setup of line-testing equipment. Commercial exchange service is handled through these two switchboards, and at Liberal the company has a branch line to its gas properties in the Hugoton field.

Twenty-seven telephones are permanently connnected between the Fritch end of the line and the Louisburg switchboard. District superintendents' dwellings, and all offices on the line have telephone installations. Drops, consisting of two wires connected to the main telephone line, are brought to within a few feet of the ground on either side of a pole, and are located at points nearest main line gate valves and at other advantageous points, such as railroad crossings, main highways and the like. From such places the line walker or telephone trouble shooter may keep in touch with, or advise, his office by means of a portable set.

The two wires constituting the drops should be separated as far as conveniently possible, and not twisted together even though insulated, for a measurable amount of resistance may be built up at such a point or a surge of current caused by lightning may weld the wires together, causing a dead short. All permanent 'phone connections are protected by the conventional setup of fuses and grounded arrestor.

Atmospheric Disturbance

Considerable trouble was at first experienced from static electricity gathered from the air. This was particularly true during wind and sand storms in western Kansas or while the temperature was undergoing an extreme change at some point along the line. Investigation proved that this interference was of an extremely high frequency nature, and although the voltage was very low the generated current had the ability to jump over insulators and across weak points. When such a discharge occurred a sharp, penetrating click would sound in the receivers.

It was assumed that this current was built up when molecules of air and dust particles came into contact with the metallic line and equalized their charge by a neutralization of potential. Following such reasoning, vacuum-tube static drains were installed to keep the gathered line charge below the point at which it would discharge in the form of a spark. The penetrating click was entirely eliminated, and the background noise due to potential neutralization cut about 60 per cent.

Maintenance

One man working under average conditions can maintain 150 miles of two-wire telephone line. His equipment includes pliers, line wire, insulated drop wire, climbers, insulators, small tools and miscellaneous equipment, and a light truck. A strong spotlight is swivel mounted on the truck for locating trouble at night.

The procedure followed by the company linemen requires them to report to the Louisburg terminal once each hour during office hours. In case trouble has developed between calls, they receive their notification of its approximate location and check to that point, or until the line is again in service. In

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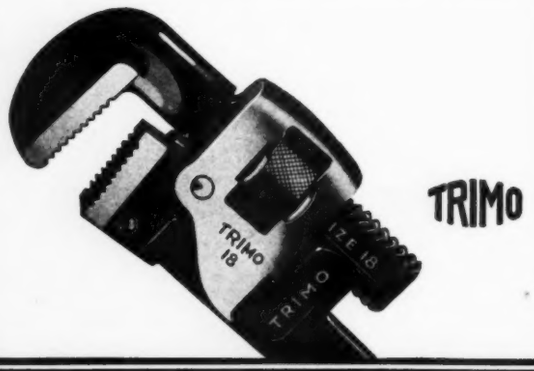

ALL STEEL **TRIMO** PIPE WRENCH

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Interior view of the Louisburg terminal showing switchboard at left, line testing equipment in the center (high-resistance voltmeter in lower case and the Wheatstone bridge to the upper right). At the extreme right are the station suction and discharge gauges.

the meantime the ordinary maintenance work is carried on, which consists of banking poles, cutting overhanging limbs, renewing split cross-arms, etc.

The cost of proper maintenance depends to a great extent upon the efficiency of the linemen and should be about $2.50 per mile per year. This includes transportation, labor, renewals due to storms and lightning, and every other item that could properly be carried under the head of maintenance.

At the Louisburg terminal, where an operator is constantly on duty, a complete test board is installed. A high-resistance voltmeter may be cut in series with the line, or the line and the ground, for determining the cause of trouble, although experienced operators can differentiate between a ground, short or open wire merely by listening on the line.

The approximate location of a short or ground is calculated by means of a Wheatstone Bridge, an instrument with variable resistance compensators, and an exposed galvanometer needle for determining equilibrium in current flow. When the indicator of the galvonometer rests on zero the resistance to the location of the trouble may be read directly from the instrument. This reading, divided by the resistance of the line per mile, gives an accurate check of the distance to the short or ground. For example, suppose that a piece of bailing wire has been thrown over the two wires, causing a short. By attaching the Wheatstone Bridge to the ends of the line and causing a current to flow out one wire, across the bailing wire, and back to the instrument, then adding known resistance to an external circuit connected to the same battery until the galvonometer shows that the resistance of the

two circuits is equal, the total of the known resistance placed in the external circuit will be the resistance of the line from the operator to the source of the trouble. Let us say that this is 1540 ohms. Dividing by 4.19 ohms (resistance per mile) will give the distance in miles, or 322.25. Multiplying by 35 (poles to the mile) places the trouble 11,278 poles from the testboard operator.

Forty-four cases of trouble were cleared on the company lines during the year of 1932. The total time the line was in trouble was 214 hours. However, during these periods, by means of a switching arrangement at both the Liberal and Louisburg stations, a circuit having the ground for one side and the two-wire metallic line for the other could be used for emergency work, although the noise level was almost as high as the voice audibility.

A complete record is kept of all cases of trouble, the files for the year of 1932 being divided as follows:

Moving of houses, combines, drilling equipment, etc., beneath wires. Wires wrapped, grounded or broken. Total cases during year, seven. Average time out, 2 hr. 30 min.

Windstorms, lightning, ice forming on wires, etc.

Wires broken, grounded or crossed. Total cases during year, 15. Average time out, 4 hr. 40 min. (Most cases due to lightning).

Other telephone or power circuits on line. Wires wrapped, crossed or externally connected. Total cases during year, seven. Average time out, 4 hr. 15 minutes.

Deliberate attempts to hinder communication. Wires shorted. Total cases during year, six. Average time out, 4 hr. 40 minutes.

Interruptions due to faulty equipment or construction. Total cases during year, four. Average time out, 6 hours.

Wire stolen from poles. Total cases during year, two. Average time out, 24 hours.

Three cases of trouble developed where the source was unknown.

Some points are definitely outstanding in the construction of the foregoing telephone system, in their relationship to the operating and maintenance costs. The use of slightly larger than ordinary wire and the large type insulators give a greater safety factor against breaks. Careful patrolling of the entire line at regular intervals removes the necessity of periodic reconditioning. The testing equipment as a means of locating trouble has definitely proven its value.

Common dry cells were used at both switchboards to actuate the telephone transmitters connected to the boards. However, as the current drain from these batteries was excessive, necessitating frequent renewals, they were replaced with six-volt storage batteries connected through a double-pole, double-throw switch to the board and to a dry rectifying, noiseless charger.

The economic practicability of the telephone as a means of contact over extensive pipe line systems has been proven. Operation costs are well within the demands of the pipe line budgets. The exacting requirements in communication have been satisfied and, considering the trends of the last few years, future developments will probably be toward more complete telephone hookups that will contact every point of pipe line operation.

The Petroleum Engineer's Fourth Annual Engineering Review Number

On June 1st the fourth Annual Engineering Review Number of THE PETROLEUM ENGINEER will make its appearance. As in the past, this issue will be comprised of a group of fact-filled articles written by engineers, superintendents and other operating men of accomplishment, presenting a complete résumé of developments during the past year in engineering practices in every operating branch.

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